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Descriptions of Larvae of Several Species of the Genus *Zale* (Lepidoptera: Phalaenidae)[1]

By Margaret R. MacKay[2]
Division of Forest Biology, Ottawa

Introduction

The larvae of the genus *Zale*, unlike typical phalaenid larvae, are long and slender, and taper anteriorly and posteriorly. The anterior pairs of abdominal prolegs are reduced in size, and the anal prolegs are usually extended behind the body. The species are closely related to those of the genus *Catocala*, with which they should not be confused.

The nomenclature of the conifer-feeding species is that used by McDunnough (1943) in his revision of the *obliqua-metatata* group, and the species *lineosa* (Walker) is the species to which Morrison's names *galbanata* and *penna* are referable (Franklemont, 1950).

Though no differences in body setal pattern could be discovered among the species studied, setal maps of the thoracic and abdominal segments, as well as of the head shield, have been included with the illustrations. The system followed in naming the setae of the segments is that of Fracker (1915), and of the head, that of Heinrich as cited in Peterson (1948). An extremely useful reference to the morphology of phalaenid larvae is the publication *Tobacco Cutworms* by Crumb (1929); and Ridgway's (1912) *Color standards and color nomenclature* has been closely followed in describing the pigmentation of the integument.

Zale helata (Smith) (form ruperti of McDunnough)
Figs. 1, 9, 14. Plate IX: Figs. 1, 2

Early instars.—Ground colour whitish-green with broad dark-green spiracular lines; lighter dorsal and subdorsal lines present but not distinct; setal bases inconspicuous. Head light tan; lighter inverted V's (described more fully under "Ultimate instar") usually present.

Intermediate instars.—Colour pattern as in early instars but more distinct; addorsal and subspiracular lines peacock green, changing to yellow or orange-green as the larva grows; spiracular line with touches of burnt sienna; setal bases inconspicuous. Head citrine with inverted V's of white.

Ultimate instar.—Measurements of specimen illustrated: head width 3.1 mm., body length 37 mm. Integument smooth, colour pattern distinct and regular; ground colour grass green to dull green-yellow. Middorsal and subdorsal lines white or almost so, narrower than addorsal and spiracular lines. Addorsal line grass green to dull green-yellow in some segments, and in some specimens edged in black in thoracic region and posterior abdominal segments. Spiracular line broad, narrowing posteriorly and extending onto anal proleg, olive green varying to citrine, or of a more even medal bronze, but always with touches of burnt sienna; edged ventrally by a narrow white line. Subspiracular area of much the same colour as addorsal, fading into light ventral area. Midventral line broken, indefinite, often absent. Setigerous tubercules small, dark-rimmed, set directly on integument except those of setae beta on the eighth and ninth abdominal segments, which are on slightly raised areas; those in spiracular and subspiracular

[1]Contribution No. 11, Division of Forest Biology, Science Service, Department of Agriculture, Ottawa, Canada.
[2]Agricultural Research Officer.

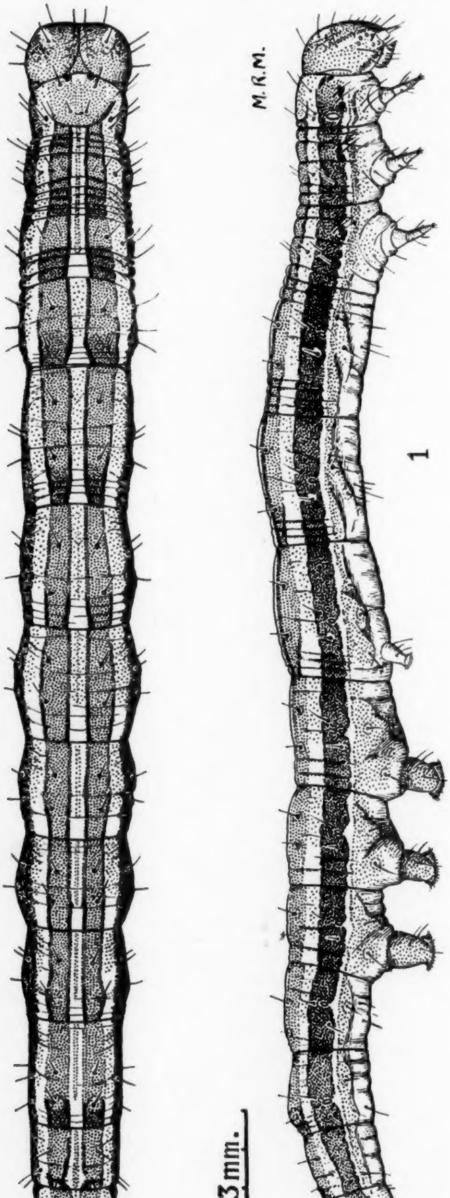


PLATE I

Fig. 1. *Zale helata* (Sm.) (form ruperti of McD.), mature larva, dorsal and lateral views.

regions surrounded by small, lighter-coloured areas of pigmentation. Setae moderately long. Spiracles oblong-elliptical; centres, ground colour with dark-brown to black rims. Prothoracic shield distinct, ground colour shading to citrine. Anal shield poorly defined, middorsal and subdorsals extending onto it. Proleg shields poorly defined. Thoracic legs and ventral prolegs, ground colour, and citrine or burnt sienna distally. Crotchets of first proleg 12 to 15 in number, those of second proleg 25 or more, and those of the third and fourth 30 to 35. Ventral prothoracic gland (Detwiler, 1922) long and tapering.

Head citrine, with few or no reticulate markings; long inverted V's of solid white extending from second pair of posterior setae (P^2) anteriorly, sometimes including first pair of posterior setae (P^1); lateral light-coloured bands extending from lateral setae (L^1) to ocelli IV. Anterior seta 2 (A^2) usually approximately equidistant from A^1 and A^3 and at the apex of a triangle formed by these three setae. Ocelli I and II close together or partially fused; distance between ocelli II and III usually about one and one-half times that between III and IV. Epicranial index about 0.6. Median longitudinal width of postclypeus less than one-half that of preclypeus. Labrum almost twice as broad as long; anterior margin moderately emarginated, sides of notch forming an angle of about 140°.

Mandible with five teeth, the first three well defined and pointed, the other two forming a notched ridge; retinaculum (Peterson, 1948) on oral surface well developed and tooth-like, connected to second and third teeth by conspicuous ridges.

Spinneret with blunt notched tip; as long as or longer than first two segments of labial palp, length about two and one-half times width. Spinneret and palps not depressed beneath lingua and usually visible in a dorsal view of hypopharynx. Lingua separated from maxillary lobes by a transverse, slightly depressed area; proximal two-thirds armed with small spines directed meso-caudally; lateral margins devoid of spines; upper surface in a lateral view curved downward toward front. Blades of maxillulae with 12 or more small, indistinct, tooth-like processes. Lobes sparsely clothed with setae. Limits of gorge usually not well defined.

Remarks.—Larvae become reddish or pinkish when ready to moult. Mature larvae become cossack green or near it in colour. In the newly formed pupa, the anterior portion is dark greenish-brown, the posterior reddish-brown; eventually the entire pupa becomes taupe brown or maroon, the characteristic colour of *Zale* pupae, and is sometimes partially covered with a white mealiness.

Hosts.—Usually white pine, occasionally red, Scotch, and jack pines, European larch. One or two specimens have been collected on deciduous growth.

Zale duplicata largera (Smith)

Figs. 2, 2A, 3, 10, 15, 22. Plate IX: Figs. 3, 4

This subspecies has two distinct colour phases in the larval instars, one in tones of rust, the other in tones of brown or brownish-grey. The maculation of the former is continuous, of the latter segmental, although the basic pattern is the same in both.

Early instars.—The two phases with patterns similar to later instars of the rust phase, but paler and less distinct. Larvae of the rust phase as follows: ground colour Sudan brown or lighter, even pale yellow-green in very young larvae; touches of garnet brown, particularly on the spiracular line, which is darker than the rest of the body; dorsal line continuous; ventral line broken; setal bases conspicuous because of extremely dark surrounding areas; head Sudan brown with almost white inverted V's and darker transverse reticulations. Larvae

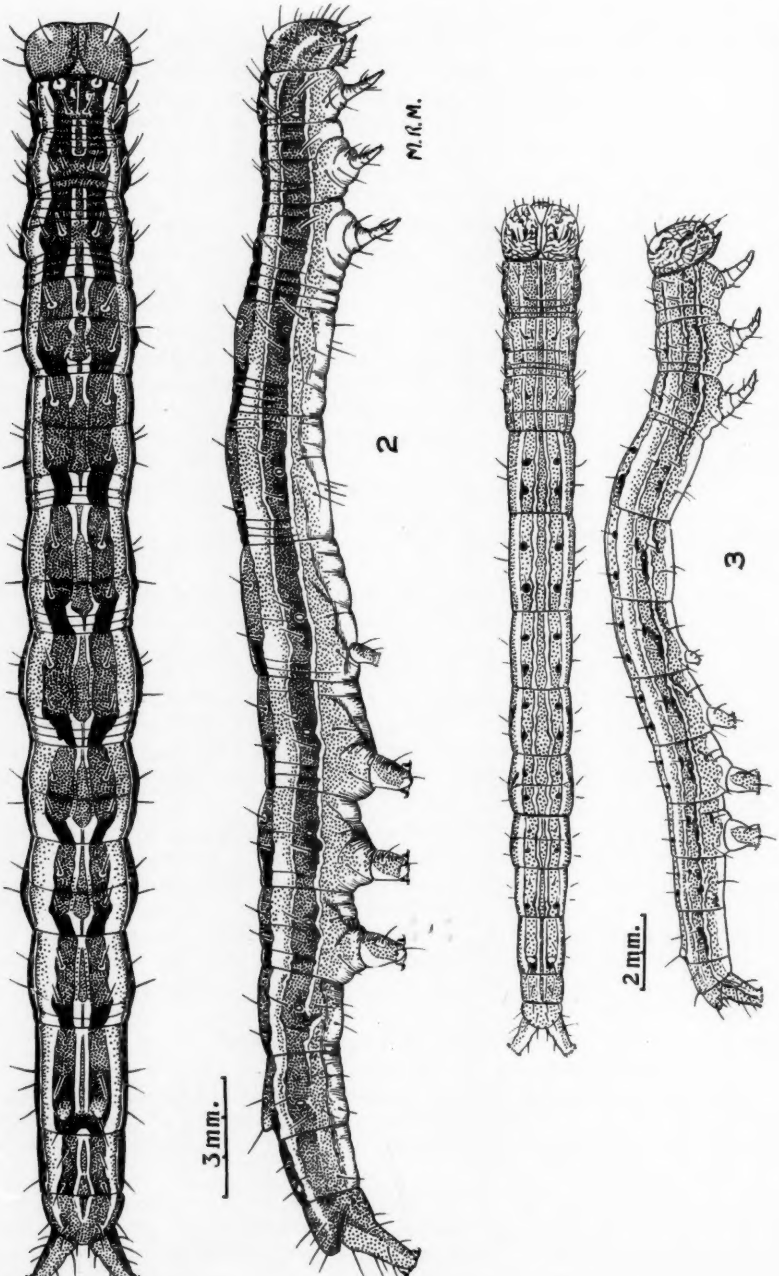


PLATE II

Figs. 2, 3. *Zale duplicata largera* (Sm.). 2, mature larva of rust phase, dorsal and lateral views. 3, young larva, dorsal and lateral views.

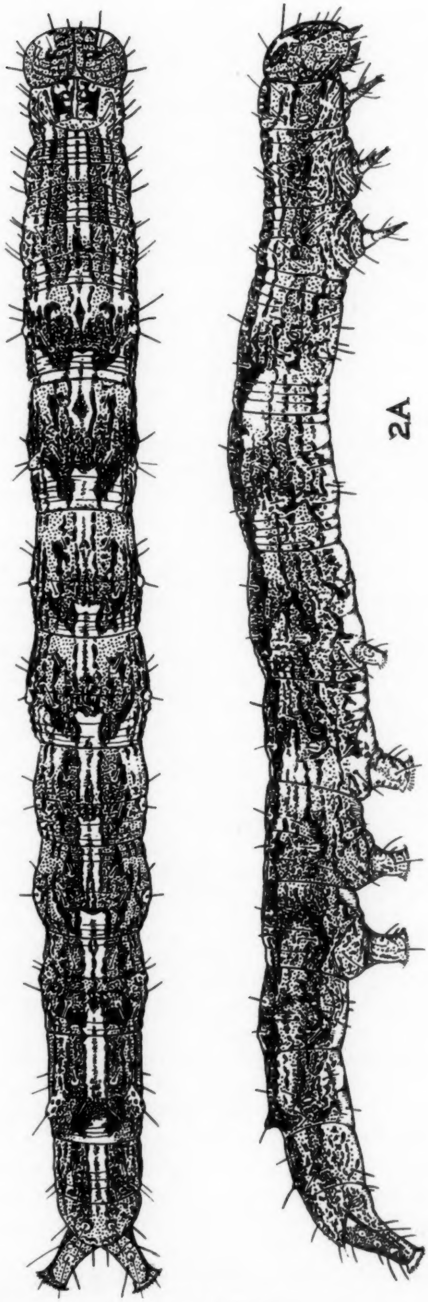


PLATE III

Fig. 2A. *Zale duplicata largera* (Sm.), mature larva of brown phase, dorsal and lateral views.

of the brown phase similar except that the ground colour is more nearly chestnut-brown, and heavily suffused with white pigment in the lighter areas, particularly the dorsum.

Ultimate instar of rust phase.—Measurements of specimen illustrated: head width 2.8 mm., body length about 40 mm. Integument smooth; colour pattern usually distinct; considerable variation in colour, but ground colour generally citrine or nearly so. Middorsal line slightly broader and more irregular than that of Z. *helata* form ruperti, citrine in middle of segment, grading to white in intersegmental areas; white area in posterior portion of segment often furcated or emarginated apically. Addorsal broader than middorsal, grading from bay posteriorly (the darkest area) to argus brown anteriorly in segment. Subdorsal about same width as dorsal, with varying degrees of white and citrine, but usually white toward posterior end of segment. Spiracular line broad, more or less bay, narrowing posteriorly and continuing indistinctly onto anal proleg; edged ventrally with a narrow white line. Subspiracular area citrine. Venter very light in colour with a distinct, narrow midventral line of garnet brown that broadens considerably between ventral prolegs, and often disappears in the intersegmental areas. Setigerous tubercules small, dark-rimmed, set directly on integument with two exceptions: the tubercles of setae beta of the eighth abdominal segment, which are on large chalazae; and those of setae beta of the ninth segment, which are on smaller ones. Setae moderately long. Prothoracic and anal shields not well defined, crossed by lines of pigment; bases of setae alpha on prothoracic shield set in large, light-coloured areas, and addorsals mottled. Proleg shields citrine. Spiracles oblong-elliptical, dark-rimmed, with centres ground colour. Crotchets of ventral prolegs numbering about the same as those of Z. *helata* form ruperti. Ventral prothoracic gland present.

Head usually Sudan brown, with darker transverse reticulations of argus brown; inverted V's of white, and lateral light-coloured bands present; arrangement of ocelli, position of seta A^2 in relation to A^1 and A^3, epicranial index, and labrum as in Z. *helata* form ruperti.

Mandibles and hypopharynx apparently also similar in all respects to those of Z. *helata.*

Remarks.—Mature larvae become uniformly citrine or Sudan brown in colour; a vague dorsal line and the darker areas of the addorsals may still be present.

Ultimate instar of brown phase.—Maculation often of considerable contrast: darkest areas purplish, reddish, or even blackish-brown (diamine brown or Hessian brown suffused with black), lightest areas white. Segmental pattern resulting from diffusion of the dark pigment of addorsals onto the median areas of subdorsal and spiracular lines. Contrast particularly noticeable in the first abdominal segment, where there is heavy suffusion of black in the brown, and considerable white on the dorsum in the subsequent intersegmental area; contrast often evident to a lesser degree in the second and fourth abdominal segments. Spiracular line not so well defined as in the rust phase. Reticulations on the head sometimes as dark as the darkest areas on the body. Some specimens with a faded pattern having no extremes of pigmentation (this condition also occurs in the rust phase).

Morphological characteristics similar to those of the rust phase.

Hosts and distribution.—This species is known to extend from Ontario westward to the Pacific coast. It is found usually on jack pine in the East and on lodgepole and white pines in the West.

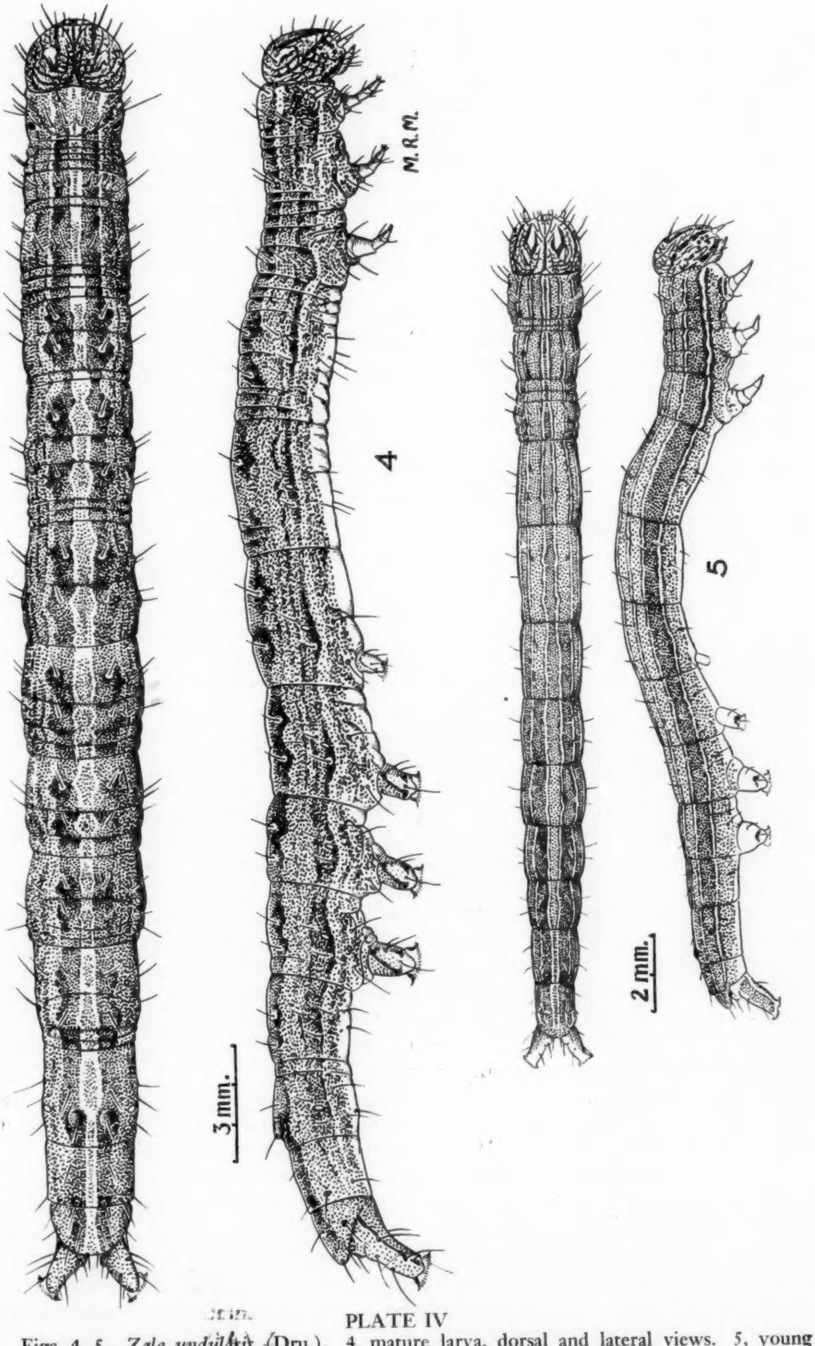


PLATE IV

Figs. 4, 5. *Zale undularis* (Dru.). 4, mature larva, dorsal and lateral views. 5, young larva, dorsal and lateral views.

Remarks.—Reared adults from British Columbia are extremely variable: there are specimens identical with the smooth-patterned eastern form; others which are mottled with a distinct, purplish-grey suffusion on primaries; some extremely rich, dark forms; and rarely, one or two resembling a specimen of *duplicata duplicata* (Beth.) that lacks the pale antemedian band. No relation has been found between larval colour phases and sex or maculation of adults.

Two adults of *Zale d. duplicata* (Beth.) have been reared from larvae incorrectly identified as of the brown colour phase, and two adults of *submediana* (Strand) from larvae presumed to be of the rust phase. What differences distinguish these species from *duplicata largera* in the larval instars remain to be discovered.

Zale undularis (Drury)

Figs. 4, 5, 11, 16, 19, 20. Plate IX: Fig. 5

Early instars.—Lightly pigmented on the dorsal surface, and darkly on the spiracular area; setal bases inconspicuous; ventral line present.

Intermediate instars.—More slender and tapering than those of the preceding species; dark, bone brown or near it in colour, the only light areas being the narrow longitudinal lines edging the dorsal, addorsal, subdorsal, and spiracular lines. Inverted V's of light pigment, and the dark, transverse, reticulate lines on the head usually apparent.

Ultimate instar.—Specimen illustrated: head width 3.0 mm.; body length about 35 mm.; broadest in segments 4, 5, 6, tapering sharply posteriorly. Integument smooth. Colour pattern never very distinct; many specimens almost unicolorous. Ground colour mauve-brown, green-brown, or black-brown. Middorsal line continuous, but of uneven width, broadening in the anterior and again in the posterior portion of many of the abdominal segments. Addorsal unevenly pigmented; usually darker at outer edges near setigerous tubercules; edged laterally on thoracic segments, and sometimes on segment eight, by a narrow, pale line. Subdorsal area ground colour with vague longitudinal interrupted lines of darker pigmentation. Spiracular line distinct on thoracic segments, pigmentation darker toward edges. Ground colour of subspiracular area extending onto posterior area of ventral prolegs. Venter white with a pinkish overtone; midventral line dark reddish-purple, distinct, almost continuous, broadening in thoracic area and between ventral prolegs particularly the first and second pair. Setigerous tubercules small, dark-rimmed, and set directly on integument with two exceptions: tubercules of setae beta of the eighth abdominal segment, which are on large chalazae; and those of setae beta of the ninth segment, which are on small ones. Setae moderately long. Spiracles oblong-elliptical, dark-brown to black rims, centres usually dark. Prothoracic and anal shields not well defined, crossed by middorsal and addorsals. Ventral proleg shield lightly sclerotized; pigmentation darkened toward edges, especially posterior edge, which forms a definite dark line. Anal proleg shield with its anterior edge forming a similar dark line. Crotchets of first ventral proleg 15 to 20 in number, of second proleg about 30, and of third and fourth 30 to 35. Ventral prothoracic gland present.

Head, ground colour with darker transverse reticulations and inverted V's of white extending forward from setae P^2, the white areas not always conspicuous; lines of dark pigmentation along the ventral edge of the cranium, and from seta P^1 to the outer edge of the clypeus, and often another just above the ocelli group and parallel to the former; adfrontal sclerites with no reticulate markings; frons pale in colour with a narrow median line of dark pigmentation; clypeus also pale with a median area of dark pigment. Anterior seta 2, (A^2) usually closer to A^1 than to A^3 and more or less in line with both of them. Ocelli I and II partially

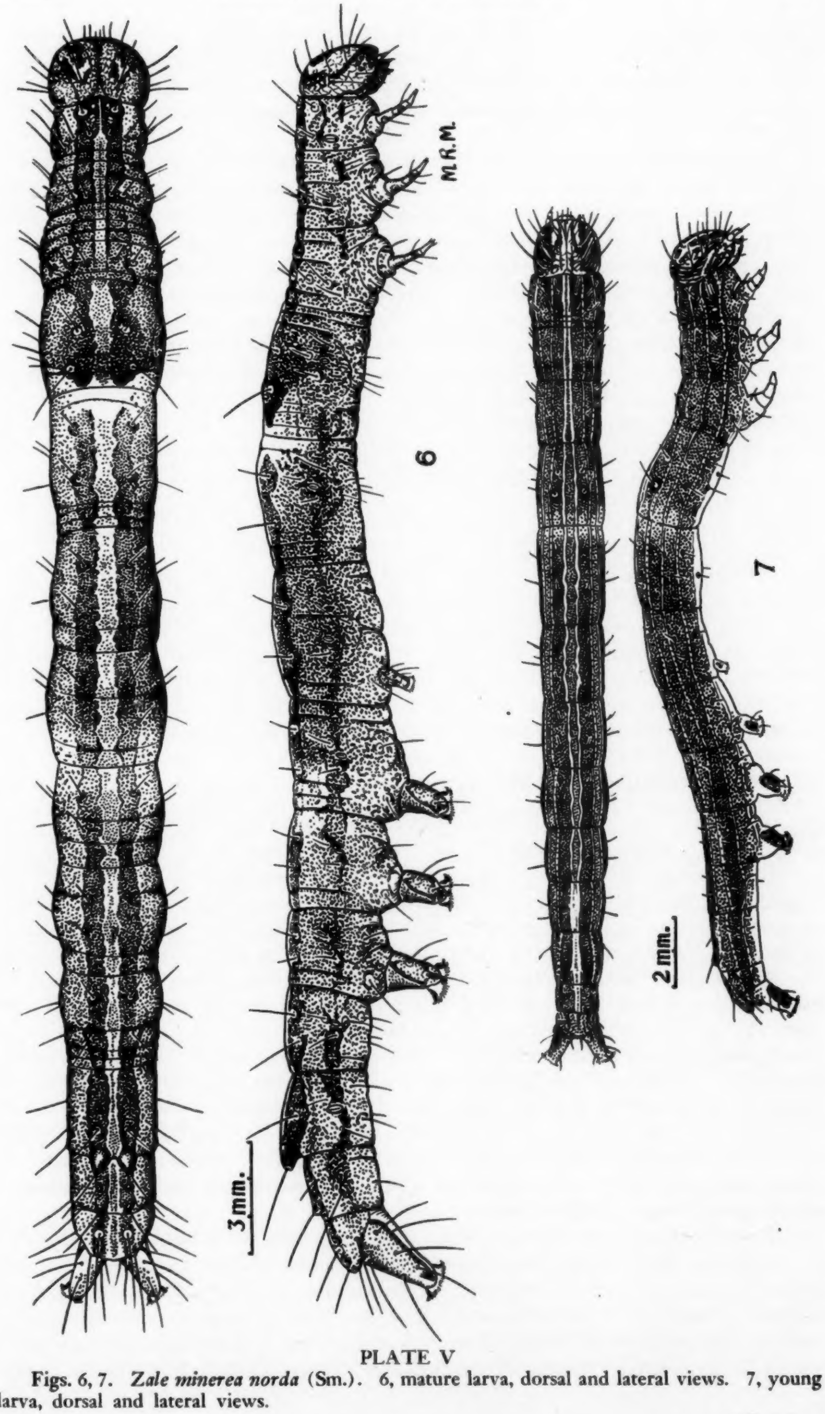


PLATE V

Figs. 6, 7. *Zale minerea norda* (Sm.). 6, mature larva, dorsal and lateral views. 7, young larva, dorsal and lateral views.

fused; distance between ocelli II and III usually about one and one-half times that between III and IV. Epicranial index 0.6. Median longitudinal width of postclypeus about one-third that of preclypeus. Labrum twice as broad as long; anterior margin deeply emarginated, the edges of notch forming an angle of about 90°.

Mandible with five teeth, the first two small and blunt, the third and fourth large and blunt, the fifth sometimes with apex obliquely pointed at an angle of 120° or 130°, but usually forming a smooth ridge; mesal tooth or retinaculum plateau-like, with grinding surface broadly concave, triangular in shape, and often jagged, particularly at the edges; two small ridges leading to retinaculum from between second and third, as well as third and fourth teeth.

Spinneret with blunt, notched tip, longer than first two segments of labial palps, length about three and one-half times width; spinneret and palps depressed beneath lingua and seldom visible in a dorsal view of hypopharynx. Lingua separated from maxillary lobes by a transverse, deeply depressed area, and armed with large stout spines on premaxillary areas and with small spines in median area; upper surface in a lateral view rising sharply in proximal portion and sloping downward steeply toward spinneret. Blades of maxillulae in the form of arm-like structures with about ten or more tooth-like processes. Lobes sparsely clothed with setae. Limits of gorge usually not distinctly defined.

Remarks.—On the basis of Ridgway's *Color Standards* (1912) the colours of two specimens were as follows: (a) Ground colour of body drab to benzo brown; addorsal lines of thorax, intersegmental areas, and other pale areas a light cinnamon-drab; dark areas bone brown, particularly on outer edges of addorsals near setigerous tubercules, becoming almost black in last three abdominal segments; venter white with pinkish overtone; midventral line reddish-purple; head light cinnamon-drab overlaid with reticulations of bone brown. (b) Colour pattern of head and body, venter excepted, almost unicolourous; pigmentation generally fuscous-black.

Hosts.—Usually black and honey locusts.

Zale minerea norda (Smith)

Figs. 6, 7, 12, 17, 23. Plate IX: Figs. 6, 7, 8

Early instars.—Much like Z. *undularis* in appearance and slenderness; dorsum, particularly dorsal line, somewhat lighter than spiracular areas; addorsals apparent; areas surrounding setal bases dark; triangular areas of dark pigment on lateral surfaces of prolegs; midventral line present; head often conspicuously patterned.

Intermediate instars.—Purplish-black or dark-grey in colour (Z. *undularis* is brown); dorsal line, addorsals, and other lines separated by narrow light lines that, except for those flanking the middorsal lines, are less distinct than the corresponding lines of Z. *undularis.* Setal bases set in small, inconspicuous dark areas with two exceptions: the tubercules of setae beta on the first abdominal segment, which are set in small white areas, these in turn being partially or wholly surrounded by dark pigmentation; and the tubercules of setae beta on the eighth abdominal segment, which are on very dark chalazae. Addorsal lines anterior to chalazae also dark. Intersegmental area posterior to first abdominal segment often lighter than ground colour.

The colours of only one larva were used in making the following description.

Ultimate instar.—Specimen illustrated: head width 3.8 mm.; body length about 38 mm.; broadest in first, fifth, and sixth abdominal segments. Integument smooth, ground colour avellaneous. Middorsal line, ground colour flanked by narrow pale lines of tilleul buff, of uneven width especially in abdominal segments (as in Z. *undularis*). Addorsal darker than ground colour, but unevenly pig-

mented; clove brown even black in thoracic region, in first abdominal segment, where it broadens onto subdorsal area, and in eighth abdominal segment; tilleul buff in anterior portion of second abdominal segment and intersegmental area between fourth and fifth segment. Subdorsal not distinct; ground colour except in anterior portion of second abdominal segment and between fourth and fifth segments, where it is tilleul buff. Spiracular line more distinct in some specimens than others, somewhat darker than ground colour. Ground colour of subspiracular line continued onto posterior area of ventral prolegs. Venter grey-green; ventral line almost unbroken in some specimens, reddish-purple, broadening in middle of segment particularly in thoracic region and between ventral prolegs. Setigerous tubercules small, dark-rimmed, set directly on integument with three exceptions: those of setae beta on first abdominal segment, which are on raised areas sometimes joined to form a transverse ridge; those of setae beta on the eighth abdominal segment, which are on prominent chalazae; and those of setae beta on the ninth segment, which are often on small chalazae; pigmentation of small area around or adjacent to tubercule of seta beta on first abdominal segment, pale, often white, and surrounding that and extending posteriorly a wedge-shaped area of clove brown; chalazae on eighth abdominal segment clove brown or black. Spiracles oblong-elliptical, rims dark-brown, centres ground colour. Prothoracic shield not well defined; addorsals mottled; areas around setal bases pale; middorsal a very narrow line. Anal shield crossed by middorsal and addorsals. Proleg shields prominent, vinaceous-buff; pigmentation darker toward edges, so that posterior edges of ventral proleg shields and anterior edge of anal proleg shield form distinct, almost black, lines. Crotchets of first proleg about 20 in number, of second about 30, of third and fourth 30 to 35. Thoracic legs avellaneous.

Head pale vinaceous-fawn overlaid with clove-brown reticulations; inverted V's of pale pigment bordered with clove-brown or black extending from setae P^2 forward on either side of setae P^1; lines of clove-brown pigmentation along ventral edge of cranium, and just above ocelli and parallel to former, and from setae P^1 to outer edges of clypeus; adfrontals, ground colour; frons, ground colour, with a median dark line; clypeus, ground colour, with a median area of dark pigment. Positions of anterior setae and of ocelli as in Z. *undularis*. Epicranial index about 0.55. Median longitudinal width of postclypeus one-third or more that of preclypeus. Labrum half to two-thirds as long as wide; anterior margin deeply emarginated, the edges of notch forming an angle of 65° or 70°.

Mandibles as in Z. *undularis*.

Spinneret and labial palpi as in Z. *undularis*. Hypopharynx closely resembling that of *undularis*, but distinguished from it by the armature of the lingua: no clear line of distinction between the lateral areas of coarse spines and the median area of smaller spines as in the former species.

Remarks.—The following brief descriptions of three specimens indicate to some extent the colour variation that may be found in larvae of this species: (a) Ground colour grayish olive; dark areas of addorsals especially on first, seventh, and eighth abdominal segments fuscous; intersegmental area between fourth and fifth abdominal segments tilleul buff, other light-pigmented areas especially the second abdominal segment and margins of middorsal line vinaceous-buff; anal shield and prolegs light grayish olive; venter grey-green with reddish-purple midventral line; head, hair brown overlaid with reticulate markings of chaetura black, inverted V's pale drab-gray with margins of chaetura black. (b) Ground

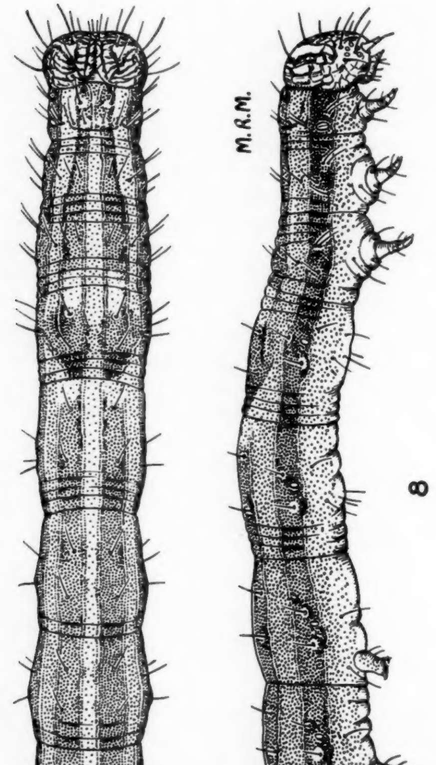


PLATE VI

Fig. 8. *Zale lineosa* (Wlk.), mature larva, dorsal and lateral views.

colour of head and body mouse gray; pale mouse gray in lighter areas, shading to black in darker areas. (c) Larva almost unicolorous, blackish-brown in most areas.

Hosts.—White birch, willow, balsam poplar, red maple, basswood, ironwood, blue beech.

Zale lineosa (Walker)

Figs. 8, 13, 18, 21. Plate IX: Figs. 9, 10, 11, 12

Larvae of this species have two distinct colour phases, the paler one a light elm green to pale dull green-yellow, the darker one olive-brown, deep olive, or drab.

Early instars.—Ground colour due to transparency of integument rather than pigmentation, light elm green to pale dull green-yellow; margins of middorsal line and narrow lines separating addorsals and spiraculars pale dull green-yellow; addorsals, spiraculars, and other lines ground colour. Head pale dull green-yellow; inverted V's of lighter pigment usually present.

Ultimate instar.—Measurements of specimen illustrated: head width 3.0 mm., body length 40 mm. Integument smooth; ground colour citrine-drab. Middorsal deep olive-buff flanked by narrow paler lines. Addorsal broader than middorsal; broadening onto subdorsal area in first abdominal segment; deep olive or drab in colour, but darker in thoracic and first, seventh, and eighth abdominal segments, and lighter in anterior portion of second segment. Subdorsal and subspiracular areas ground colour. Spiracular deep olive. Venter pale olive-buff; midventral line lacking. Setigerous tubercules small, dark-rimmed, set directly on integument except those of setae beta on the eighth abdominal segment, which are on small chalazae; and those of setae beta on the ninth segment, which are on slightly raised areas; chalazae and raised areas extremely dark. Prothoracic shield distinct in some specimens; middorsal narrowed to a pencil line; addorsals unevenly pigmented, pale at setal bases. Anal shield crossed by middorsal and addorsals. Proleg shields ground colour with dark margins, latter not always distinct in pale specimens. Spiracles oblong-elliptical, with dark rims and pale centres. Crotchets of first proleg 12, 15, or more, of second 20 to 25, of third and fourth 25 to 30. Thoracic legs more or less ground colour.

Head deep olive-buff; darker reticulations present but not conspicuously so, even in dark specimens; inverted V's of pale olive-buff from setae P^2 forward on either side of setae P^1. Positions of anterior setae and of ocelli as in Z. *undularis*. Epicranial index 0.6. Median longitudinal width of postclypeus one-third or more that of preclypeus. Labrum about twice as broad as long; anterior margin emarginated, sides of notch forming an angle of about 100°.

Mandibles as in Z. *undularis*.

Spinneret and labial palps as in *undularis*. Hypopharynx closely resembling that of *undularis* but distinguished from it by the armature of the lingua: proximal half of lingua armed with slender spines in premaxillary areas, and smaller ones in the median area.

Host.—Manitoba maple.

Remarks.—This species has two generations a year; some adults emerge in the spring and others in August.

Key to Mature Larvae of Species Studied

1. Labrum with shallow emargination (Figs. 14, 15); seta A^2 on head shield approximately equidistant from A^1 and A^3, and at apex of a triangle formed with A^1 and A^3 (Fig. 24); mandible with blunt internal tooth (Figs. 9, 10); spinneret and labial palps not depressed beneath lingua, usually visible in dorsal view of hypopharynx (Fig. 22) ... 2

Labrum with moderate to deep emargination (Figs. 16, 17, 18); seta A^2 on head shield usually, but not invariably, closer to A^1 than to A^3, and more or less in line with both

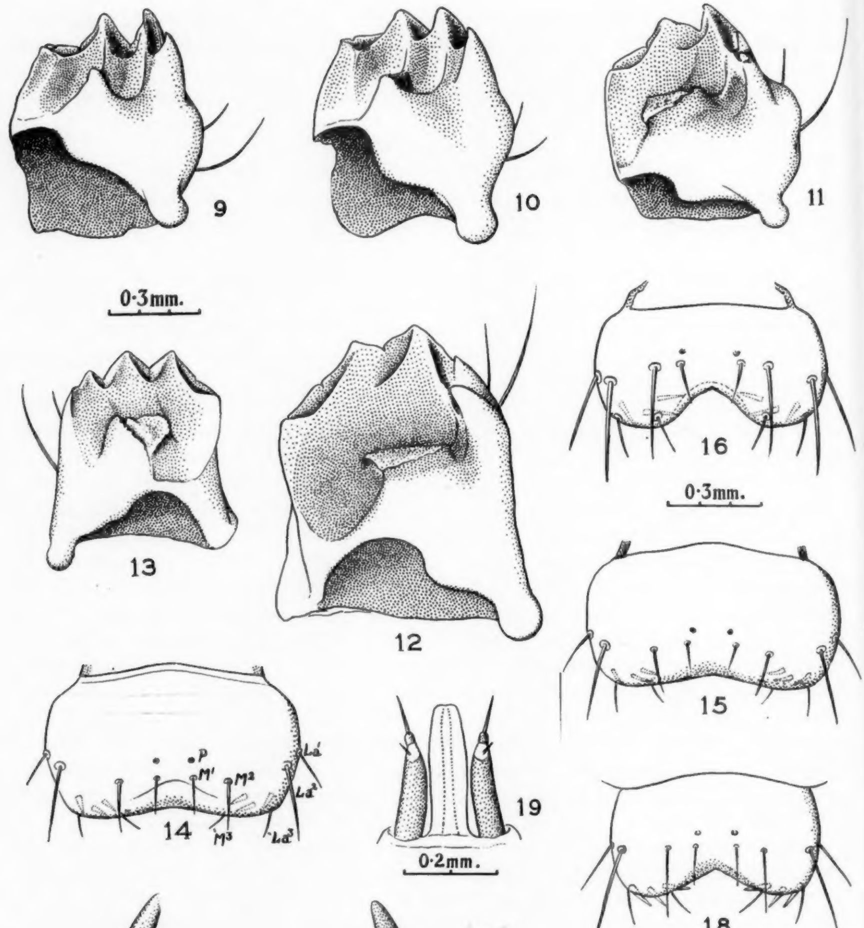
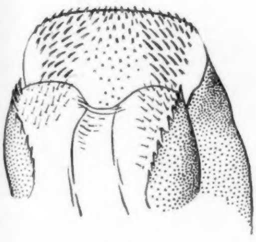


PLATE VII

Figs. 9-20. 9, Z. *belata* (Sm.) (form ruperti of McD.), mandible. 10, Z. *duplicata largera* (Sm.), mandible. 11, Z. *undularis* (Dru.), mandible. 12, Z. *minerea norda* (Sm.), mandible. 13, Z. *lineosa* (Wlk.), mandible. 14, Z. *belata* (Sm.) (form ruperti of McD.), labrum. 15, Z. *duplicata largera* (Sm.), labrum. 16, Z. *undularis* (Dru.), labrum. 17, Z. *minerea norda* (Sm.), labrum. 18, Z. *lineosa* (Wlk.), labrum. 19, Z. *undularis* (Dru.), spinneret and labial palps. 20, Z. *undularis* (Dru.), hypopharynx.



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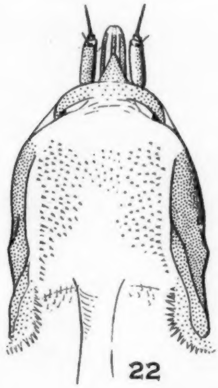

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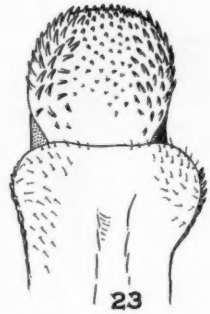

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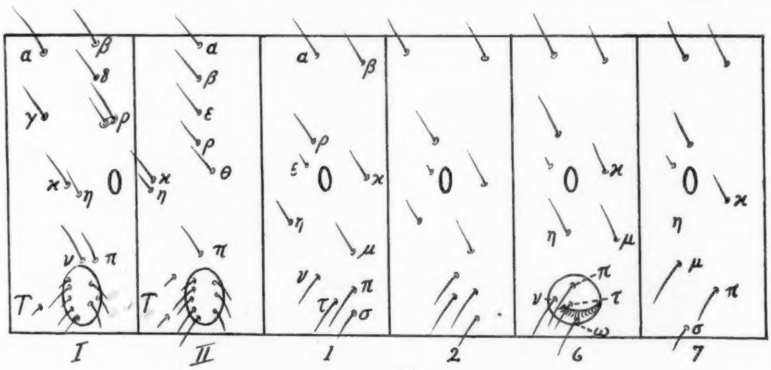

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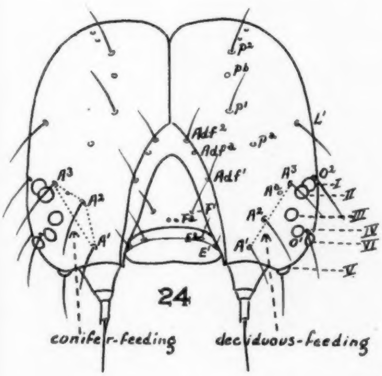

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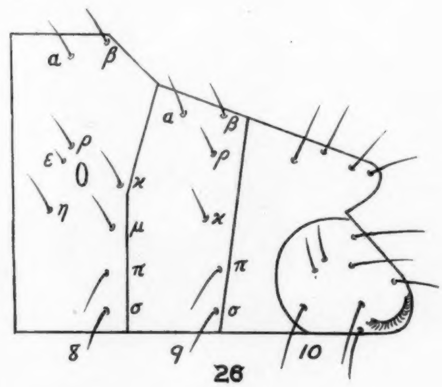

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PLATE VIII

Figs. 21-26. 21, Z. *lineosa* (Wlk.), hypopharynx. 22, Z. *duplicata largera* (Sm.), hypopharynx, spinneret, labial palps. 23, Z. *minerea norda* (Sm.), hypopharynx. 24, *Zale* spp., setal map of head shield; usual arrangement of setae A of conifer-feeding species on left (Z. *d. largera* figured), and usual arrangement of setae A of deciduous-feeding species on right (Z. *undularis* figured). 25, Z. *duplicata largera* (Sm.), setal map of first and second thoracic segments and of first, second, sixth, and seventh abdominal segments. 26, Z. *duplicata largera* (Sm.), setal map of eighth, ninth, and tenth abdominal segments.

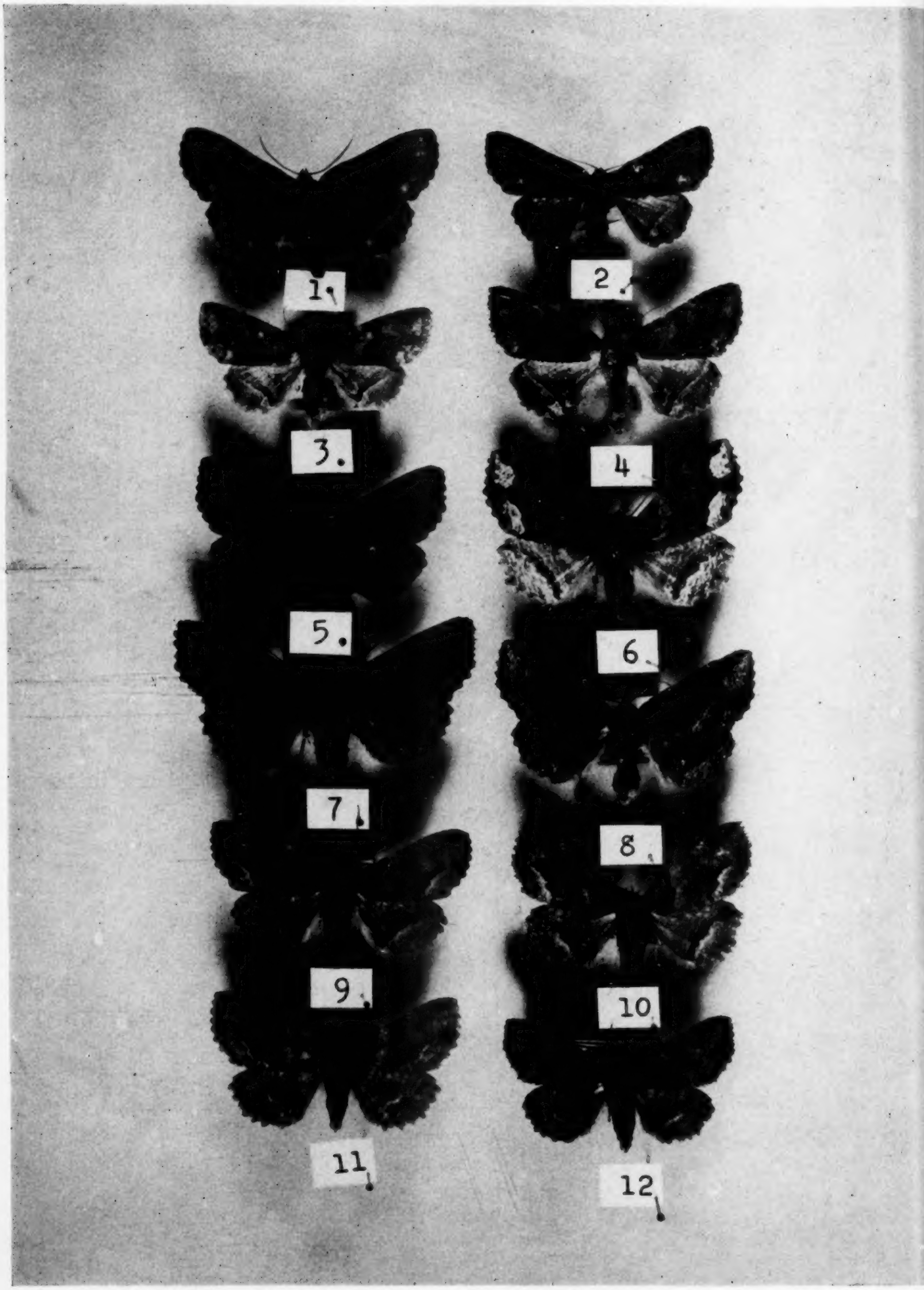

PLATE IX

Figs. 1-12. 1, 2, Z. *helata* (Sm.) (form ruperti of McD.), adults. 3, 4, Z. *duplicata largera* (Sm.), adults. 5, Z. *undularis* (Dru.), adult. 6, 7, 8, Z. *minerea norda* (Sm.), adults. 9, 10, 11, 12, Z. *lineosa* (Wlk.), adults.

(Fig. 24); mandible with surface of internal tooth broadly concave or flattened (Figs. 11, 12, 13); spinneret and labial palps depressed beneath lingua, seldom visible in dorsal view of hypopharynx 4

2. No prominent chalazae; midventral line indistinct or lacking; longitudinal colour pattern green and white with rust-coloured spiracular area; host usually white pine .... *belata* (Sm.) form ruperti of McD.

Setae beta of eighth abdominal segment on chalazae; midventral line present 3

3. Longitudinal colour pattern rust and white; hosts, jack pine and red pine in East, lodgepole and white pine in West .... *duplicata largera* (Sm.) if eastern locality, possibly *submediana* (Strand)

Segmental colour pattern, tones of brown or grey .... *duplicata largera* (Sm.) if eastern locality, possibly *duplicata duplicata* (Beth.)

4. Midventral line lacking; lingua of hypopharynx armed with slender spines (Fig. 21); setae beta of eighth abdominal segment on small chalazae; two colour phases: pale green, and olive or drab; host, Manitoba maple .... *lineosa* (Wlk.)

Midventral line present; lingua of hypopharynx armed with stout spines 5

5. Setae beta of first abdominal segment on raised areas sometimes joined to from a transverse ridge; setae beta of eighth abdominal segment on prominent chalazae; lingua of hypopharynx with no clear line of definition between areas of coarse and fine spines (Fig. 23); ground colour more gray than brown; areas between first and second, fourth and fifth abdominal segments usually distinctly pale; addorsals on first and eighth abdominal segments very dark; hosts, white birch, willow, ironwood, and other deciduous trees *minerea norda* (Sm.)

Setae beta of first abdominal segment not on raised areas; setae beta of eighth abdominal segment on chalazae; lingua of hypopharynx with clearly defined areas of coarse and fine spines (Fig. 20); colour pattern more brown than grey, not distinct; hosts black and honey locusts .... *undularis* (Dru.)

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The Specificity of Host Relations in Predacious Insects*

By W. R. Thompson
Commonwealth Institute of Biological Control
Ottawa, Canada

It is well known that no living organism can continue to multiply indefinitely. Sooner or later environmental factors combine to slow down the rate of increase and eventually bring it to a halt. This is the phenomenon we call "natural control". Among the environmental factors responsible for the natural control of insect pests, parasitic and predacious insects sometimes play an important part.

A parasitic insect is one which subsists on a host which continues to live during the feeding period. Predacious insects also feed on living hosts but they kill them at the moment of attack. Insects that feed on dead hosts are called saprophagous. The vast majority of the insects the entomologist calls parasitic are so only in the larval stage. In the adult condition they are free-living. For this reason some workers call them parasitoids but I have never seen any particular reason to use this term. Things in nature do not usually correspond exactly to our definitions and an attempt to produce an absolutely precise nomenclature simply results in the multiplication of technical terms beyond all reason.

The difference between the parasitic and predacious habits as we have defined them entails differences in behaviour which are of considerable importance from the economic standpoint. The larva of the parasitic insect is associated either alone or in company with other individuals of its own species with a single host on which it grows to maturity. The predacious insect, killing the host which it attacks, at the moment of its attack, requires a large number of individual hosts in order to complete its development. Furthermore, parasitic insects are usually carnivorous only in the larval stage. In the adult stage they feed on the nectar of flowers and so forth. Predacious insects are normally carnivorous during the whole life-history. Other things being equal the predacious insect would therefore appear to have a greater power of destruction than the parasitic insect and thus a greater importance as an agent or factor in natural control.

The parasitic insects important to the economic entomologist exist chiefly in the orders of the Hymenoptera and the Diptera. Predacious insects are found in a number of orders, particularly among the Hemiptera, Neuroptera and Coleoptera. It is not necessary for the purpose of this argument to give a catalogue of all these groups.

The significance of the difference in habit of parasitic and predacious insects from the standpoint of the general theory of natural control may be reduced to two facts. The first is, that the predator consumes more individual hosts during the course of its life history than does the parasite, destroying a multiplicity of hosts instead of one. The second is that the predator has to make contact with a multiplicity of hosts while the parasite need find only one. These two advantages appear in a sense to balance and cancel out. In fact, their significance is variously appreciated in the theory of biological control and the interaction of populations, depending essentially on the concept of insect behaviour that we take as the basis of our theoretical studies.

Since the larva of the parasite consumes during its life only one host while the larva of the predator consumes many, the destructive power of the predator and therefore its importance as a controlling agent would appear to be much superior to that of the parasite. But the parasite, in order to ensure its development to maturity, need make only one trip from the place where the host is not

*Paper presented to the June 1951 meeting of the Royal Society of Canada in Montreal.

to the place where the host is, whereas the predator is obliged to make many trips, in fact, as many as the number of hosts it consumes. Now the significance of this last mentioned difference depends essentially on whether we regard the movements of the organisms concerned, with respect to the hosts they require for their development, as random movements or non-random movements.

Random movement is movement which is totally independent of the *terminus ad quem* or the end which it eventually attains. Non-random movement is movement conditioned or determined by this end. Of an organism making a random movement we must say that it is not going anywhere in particular. An organism making a non-random movement is going somewhere from the inception of the movement.

Some of the theories of the interaction between population of entomophagous insects and the population of their hosts postulate explicitly or implicitly that parasites and predators find their hosts by random movements. Other theories postulate implicitly or explicitly that this movement is non-random. The most important theories involving the concept of random movement appear to be transpositions of physical theory, such as the theory of gases, into the biological field. In the physical theory of gases the elementary particles are considered to move at random, so that contacts between them are a simple function of the density of the mass of particles or in other words of the number of particles per unit of volume. This theoretical conception makes the efficiency of a parasite or predator as an agent of natural control very strictly dependent on the density of the host population. If this theory is correct the predator is obviously in an inferior position as compared to the parasite because it requires a multiplicity of hosts in order to complete its development. As it destroys this succession of individual hosts it steadily decreases the density of the host population and thus steadily decreases its own chance of survival. When the parasite larva has obtained a host, it remains in it for the rest of its life. No reduction in the density of the host population is produced until the parasites actually emerge, when they are of course ready to pupate.

On the other hand if the action of entomophagous insects is strictly non-random, the progressive reduction in density effected by the predator, as it devours a succession of hosts will be of no importance and in this case it is clear that the predator will be a much more effective controlling agent than the parasite because of the fact that it destroys a multiplicity of hosts during its life-history, instead of one.

Now if the movement of the parasite or predator with respect to its host is completely or even partially independent of the density of the host population this can only be because the movement is directed from its inception toward the host no matter what the distance separating them is, or at all events, is not strictly a function of this distance. This implies that the host exerts on the parasite or predator a specific attraction which is felt or perceived by the parasite, this perception being to some extent at least independent of distance. Furthermore when the parasite perceives the host it must move toward it. If its action is to some extent independent of host density, that is, independent of the exact value of the space to be traversed, then the organism must increase its effort as the difficulty of attaining the host increases. Since insects have a well developed set of sense organs and possess like other organisms the power of adaptation they can meet these requirements.

Now predators, like parasites, have a full complement of sense organs and there is no doubt that they can perceive their host at a distance, or at least perceive objects at a distance. However if the parasites are to find their hosts to a

degree independent of the host density they must not only be able to perceive their host at a distance but also must also be specifically attracted by them.

We know from the mass of records we possess that many parasites are very specific in their host relations but not much is known about the specificity of predators. A few species, for example, the celebrated *Rodolia cardinalis* Muls., the Coccinellid enemy of the fluted scale and *Cryptognatha nodiceps* Marsh., the Coccinellid enemy of the Coconut Scale, are known to be very specific in their habits. But the great majority of predators are usually considered as non-specific and general feeders. This idea is no doubt based partly on ignorance of the habits of predators which are difficult to observe in nature with accuracy and partly on the known fact that they have to consume a considerable number of individual hosts during their life-history. It is I think generally felt that insects with such a habit are probably not at all particular as to the choice of food.

An understanding of the behaviour of predacious insects and more particularly of the specificity or non-specificity of their host relations is therefore very necessary in any attempt to evaluate the importance of predators as controlling agents of injurious pests.

A practical experiment which I have been conducting for some years in Bermuda with Diaspine scale feeding Coccinellids has thrown some light on this question. At the beginning of 1947 I was invited by the Government of Bermuda to visit the Island in order to organize biological control work against two important scale insects attacking the so-called Bermuda Cedar. The Bermuda Cedar is not a cedar but a juniper, the *Juniperus bermudiana* of Linnaeus which is a species peculiar to Bermuda and very different from the ordinary *Juniperus communis* of Canada. This tree has constituted from time immemorial the forest cover of the Island of Bermuda. It is rather an attractive tree which has in the past contributed greatly to the scenic beauty of Bermuda and is greatly prized by the inhabitants of the Island as their National tree. Unfortunately during the years prior to 1947 two Diaspine scales were accidentally introduced probably on coniferous trees imported from California and in a relatively short time these spread rapidly over extensive areas causing a very rapid mortality in the Bermuda cedars. The two scales in question are *Diaspis visci* Schr., of European origin and an oyster-shell scale currently known under the name of *Lepidosaphes newsteadi* Sulc. *Lepidosaphes newsteadi* is a European species but a comparison of material makes it doubtful that the European and Bermudian scales are the same. It is possible that the species introduced into Bermuda actually came originally from the Orient.

I began work on this problem in Bermuda in January 1947. A survey of the Island then showed that *Diaspis visci* already extended in a fairly heavy infestation over about four miles in the central part of the Island which is only about 19 miles long and about 2 miles wide at the widest part. In the eastern end of the Island another area of considerable extent was severely infested with *Lepidosaphes* which was fatal to trees at a very low density. Observations during the next few months showed that the infested area was much larger than it appeared during the preliminary examination and by the end of the year *Diaspis* could easily be found right out to the eastern end of the Island, and had extended considerably in the western direction also. In the central part of the Island, around the original centre of infestation, large numbers of trees were already dead or dying.

A thorough survey of the parasites and predators attacking the scale insects was at once started and was carried on for several months. This showed that

the scale was attacked by several species of Chalcids of the family Aphelinidae of which the most important was a species described under the name of *Aspidiotiphagus lounsburyi* B. & P. from Madeira. Later investigations showed that this scale was present on *Diaspis visci* in California and probably entered the Island on scale infested trees imported from that region. Parasitism of Diaspis by *Aspidiotiphagus* and other Aphelinids of minor importance frequently ran from 80% to 90% or more. *Aspidiotiphagus* was found exerywhere, even where the density of the scale population was quite low. There was therefore some reason to hope that within a relatively short time the parasite would wipe out the scale or reduce it to a level so low that it would be of no further importance. However, it did not seem safe to count on this.

Observations showed conclusively that *Aspidiotiphagus* bred continuously throughout the year. It was by far the most abundant parasitic species constituting over 99% of the parasite population but three or four other species of Aphelinids were also present. For this reason it was thought desirable to introduce natural enemies of another type so we naturally turned to the Diaspine-scale feeding Coccinellids. From the results of the survey taken in conjunction with the entomological records available for Bermuda it had been determined that only one species of this type existed in the Island. This is the well known ladybird *Rodolia cardinalis* which is a specific enemy of the fluted scale. The fluted scale is an entirely different type of scale which is never found on the Bermuda Cedar. It might be supposed that the Island of Bermuda is essentially unsuitable for Coccinellids but we had no grounds for this hypothesis. It appeared on the contrary that the absence of these insects in Bermuda is due to the extreme isolation of this Island which is separated by about 600 miles of ocean from the nearest land. Attempts to effect the biological control of insects introduced from other countries rest ordinarily on the assumption that these insects are attacked in the native home by beneficial species which keep them in control, at least to some extent. The usual procedure followed in such cases is therefore to look in the native home of the insect for these enemies. Since the Cedar Scales were believed to be species of European origin a search for their parasites and predators would have been made in Europe if this had been possible but the unsettled conditions at the time the work was begun and the difficulty of placing staff in the European area made it difficult to organize such work. Furthermore this was not considered essential since it was believed that predacious insects in general and ladybirds in particular were not extremely specific in their host relations. It therefore seems that if we restricted ourselves to the ladybirds known to feed on Diaspine scales we might hope to secure satisfactory results by the introduction of almost any species.

It was of course possible that some at least of the introduced ladybirds might prefer other scales if they were equally common and accessible. However as it happens there are not many Diaspine scales in Bermuda and those that exist are not very common. *Diaspis pentagona* Targ., known in Bermuda as the Oleander Scale, was very abundant at one time and threatened indeed to wipe out the Bermuda Oleanders but the introduction of parasites from Europe brought this scale under control so it is now rather difficult to find in the Island. About the only other common scale is *Comstockiella sabalis* Comst., the palmetto scale, but the palmetto (*Sabal bermudana* Bailey), though native to Bermuda is not now very common in the Island. In short the Cedar Scales certainly constituted over 99.99% of the food available to a Diaspine feeding Coccinellid. It seemed therefore that the introduced ladybirds would practically have to feed on this scale and since they were not believed to be very specific in their habits it was thought that they would probably rather do this than die.

On the basis of this hypothesis and with the help of entomological colleagues in various parts of the world, large importations of Diaspine scale feeding ladybirds were immediately organized. In 1947 and 1948 some thirteen species of scale feeding Coccinellids were introduced from North America, the West Indies, South Europe and Mauritius. One of the species obtained from Mauritius had been originally introduced from the East Indies and two of the species obtained from North America were of Australian origin while another was East African. These species represented seven tribes of the sub-family Coccinellinae. They differed somewhat in their habits. One species, the Australian *Orcus chalybeus* Boisd., lays clumps of erect bright yellow eggs on branches and twigs bearing scales so that the ladybird larvae after hatching have to search for their food but the majority of the species deposited their eggs underneath the scale insects, a habit which, as C. P. Clausen has pointed out, has some affinity with the genuine parasitic habit, since the female places the offspring in immediate contact with the prey. The species introduced in 1947 and 1948 were *Ayza trinitatis* Marsh, five species of the genus *Chilocorus* namely *bipustulatus* L., *cacti* L., *distigma* Klug, *nigritus* F. and *bivulnerus* Muls.; *Curinus caeruleus* Muls.; *Cryptognatha nodiceps*; *Exochomus quadripustulatus* L.; *Egius platycephalus* Muls.; *Lindorus lophanthae* Blaisd.; *Orcus chalybeus*; and *Zagloba ornata* Horn as well as one or two other West Indian species introduced only in very small numbers.

Over 30,000 individuals of this group of species were liberated in the Island of Bermuda in 1947 and 1948. The size of the colony of the various species varied from a couple of dozen in *Exochomus quadripustulatus* to over 10,000 in *Lindorus lophanthae*. Since, as I have already said, the Island of Bermuda is quite small and the food supply was abundant it was believed that a colony of 100 individuals or so would probably be sufficient to establish a species. The introduction of large numbers was made so as to cover the Island thoroughly as soon as possible.

Most of the species introduced had been recorded in the literature as feeding on a number of species of scale insects and in some cases even on Aphids and mealybugs and the hosts in turn were known to occur on a considerable variety of plants. However it was thought wise to make some experimental tests so as to know what might be expected from releases in the field. Lots of 20 or 30 individuals of the various species were therefore placed in large cloth bags tied on infested branches of cedar in the field in a number of different localities. These experiments showed that *Ayza trinitatis*, all the species of *Chilocorus*, *Lindorus lophanthae*, *Orcus chalybeus*, and *Zagloba ornata* all bred freely in the bags on the Cedar Scales. It did not appear that conditions in the bags were either markedly more favourable or less favourable to the ladybird than outdoor conditions.

At the time the work was started none of the species liberated was known to occur on *Diaspis visci* with the exception of *Zagloba ornata* which had been collected on it in California and *Chilocorus bipustulatus* which was said to have controlled this scale on Cypress in North Africa.

The results of the bag experiments encouraged us to hope that most of the introduced Coccinellids would become established on the Cedar Scales and produce an important controlling affect. However the practical results obtained were quite disappointing. It is true that when colonies of several hundred ladybirds were released on a scale infested cedar the individuals remained on it for a considerable time and appeared to be feeding on the scales. Nevertheless very few larvae were ever seen outside the bags and in the few cases where

they were observed they probably represented a migration from bag covered branches. In spite of the large liberations made all of the species of ladybirds with one exception gradually disappeared from the trees. It was at first thought that they might be hibernating somewhere as a good many Coccinellids retire into hibernating quarters fairly early in the season but subsequent observations failed to reveal any trace of them either on the cedar scales or on any other scales existing in Bermuda. The only exception was *Lindorus lophanthae*. Within the course of a month or two after the initial large liberations of this species, larvae began to turn up on the material collected in the field and by the end of the year this Coccinellid had become relatively common. In March 1948 one heavily infested cedar branch gave by beating over 50 larvae and adults of this ladybird. It must be said that from the beginning this species had showed a very strong disposition to frequent cedar and feed on cedar scales.

Eventually *Lindorus lophanthae* multiplied to such an extent that it could be found on practically every scale infested cedar in Bermuda and it has markedly reduced the scale infestations though not to an extent sufficient to save the majority of the cedars from decline since as I have already said they are for some reason extremely susceptible to scale insect attack.

Thus in spite of the common belief and the indications given by the literature, the Coccinellids introduced into Bermuda, representing as I have said, a large variety of species belonging to a number of different tribes, showed themselves to be remarkably specific in their habits. Although they clearly could feed and breed on the Cedar Scales they did not do so when allowed to follow their own inclinations. The results obtained in 1948 have been confirmed by subsequent observations for up to this time no species of those mentioned above, other than *Lindorus lophanthae* has been recovered in the field.

The facts are rather difficult to interpret. If we say that specificity in host relations has prevented the establishment of the various Coccinellids in Bermuda we are perhaps including many different factors under the same heading. Often unsuitable climatic conditions prevent the establishment of a parasite or predator in some part of the area over which the host insect is distributed. This may be due to the fact that the extreme temperatures, though not injurious to the host, are lethal to the parasites; or to differences in reaction of host and parasite so that their life-histories do not synchronize in the proper manner, with the result that the parasite is not ready to attack the host at the proper time. In certain cases parasites will attack an insect host on one plant and neglect it more or less completely on another. In other cases a parasite or predator may be exterminated by enemies that do not exist in the country where it originated. In some instances a parasite will attack a host willingly enough but cannot live in it. In others as experiment has shown it will not attack a host in which it can live.

We have not yet had time to investigate all these possibilities. However it does not seem at all likely that the climate of Bermuda was detrimental to the introduced daybirds. Bermuda lies at the northern edge of the coconut belt. The climate is sub-tropical, mild and moist. It practically never freezes. Rainfall is well distributed throughout the year. Citrus fruits and bananas produce well and many tropical plants and trees flourish in the Island. Even in the drier months there is an abundant supply of moisture on the vegetation in the form of dew. Since *Diaspis visci* breeds continually all the year around and individuals in all stages can be found at any time it does not seem that differences in developmental rates between predators and hosts can be of any particular importance. It is possible that lizards and insectivorous birds devoured some of the ladybirds. But these insects are supposed to be distasteful to birds at least

in the adult stage and neither the bird nor the lizard population is very large. Ants may be of some importance. In fact we now think that they have interfered considerably with the increase of the ladybird population but though they have been observed to attack *Lindorus* larvae this species has gone on increasing in spite of the presence of ants. It hardly seems likely that they actually exterminated the other species of ladybirds.

It has been suggested that an important factor is the character of the foliage of the Bermuda juniper. In this tree the leaves are short and very closely appressed. The scales are normally found on the leaves, each scale being covered about half way by the leaf immediately above it. The leaves are rigid and hard to move. It must therefore be rather difficult for the Coccinellids and more particularly the large species to get a grip on the body of the scale. Furthermore the scale is not large and in any ordinary batch examined a good many have already been destroyed by parasites. Nevertheless, this must be one of the problems normally encountered in the lives of scale feeding Coccinellids and one would not think it is of major importance or in any event sufficiently serious to prevent the establishment and survival of these insects in an area where food of the class required is after all extremely abundant. The fact that many of the introduced ladybirds survived, oviposited and produced a good number of offspring which developed successfully on the Bermuda scale, when the adults were confined in bags on the cedar, shows conclusively that the food supply is not radically unsuitable.

The conclusions to which these facts lead us I think is that even in predacious insects which are mobile and free living there is a high degree of specificity in host relations. To explain the facts we must I think go even further and say that there is a high degree of specificity in the selection of an environment. There is a very striking case of this in *Orcus chalybeus* which as has been said, was one of the Australian ladybirds introduced into Bermuda from California. A number of years ago this ladybird was distributed over an area about 250 miles long stretching from San Diego to Santa Barbara in Southern California but according to the Californian entomologists it now exists only in the region of Carpinteria and Goleta opposite the Santa Barbara channel. In these two areas which are apparently more humid than the rest of southern California and lie close to the ocean *Orcus chalybeus* appears occasionally in considerable numbers in citrus orchards. We know of course that certain Coccinellids are extremely specific in their choice of hosts. The West Indian species *Cryptognatha nodiceps* which was introduced into Fiji for the control of coconut scale *Aspidotus destructor*, by Taylor and practically eliminated the scale from the Island is one of these highly specific forms. Taylor attributes its success to its very specific habit. For this reason we did not expect it to thrive in Bermuda and in the initial experiment it showed a very marked distaste for cedar and cedar scales. But, as I have already said many of the other introduced species have been recorded from very long list of different host insects living on quite different plants and many of them have a very extensive geographical range. The published records of behaviour and distribution thus seem difficult to reconcile with the results of the Bermuda introductions. However I believe that as this subject is more closely studied it will be found that the published records are not entirely reliable, at least as a guide to the result we may expect from the transfer of predators from one host to another or from one country to another. In the first place it is probable that the various species of ladybirds do not actually feed or at least feed habitually on all the various host insects with which they are associated in the records. Since these insects are free living

and highly mobile they may be easily found from time to time associated with insects which are not their true hosts. The very fact that they are found on a plant infested by one of these insects naturally gives rise to the belief that there is a real food relationship although in many cases this has not really been tested or observed. In the second place it is quite probable that all of the groups recorded under the same specific name do not really belong to that species or if they do are genetically distinct constituting a series of genotypes within the species. The studies of W. J. Brown on leaf-feeding beetles have convinced him that many of these are far more specific in their food habits than had been suspected and this I think is substantially the result obtained in the tests made of various plant feeding species introduced in other countries. Such species being mobile are quite frequently collected on plants on which they do not really feed and the gradual accumulation of such records in the literature finally gives a picture which may be completely inaccurate in so far as the real behaviour and food habits of the species are concerned. In reality although predators may be a good deal less specific in their food habits than parasites the difference is not I suspect as great as we have been led to believe. Certainly there seems now no reason to think that insect predators are so casual in their food relations that their behaviour can be described in any sense as random action. In reality their behaviour just like their morphological characteristics is specific and adaptive but the adaptive action is based, so to speak, on a foundation of specificity. The understanding of what we call specificity is one of the most important problems involved in the scientific investigation of biological control and in attempts to establish this phase of economic entomology on a scientific basis. The example of the Bermuda introduction shows very clearly the immense practical importance of this biological problem.

The Odonata of the Northern Insect Survey

By E. M. Walker
Royal Ontario Museum of Zoology
Toronto, Ontario

During the year 1950 I enjoyed the opportunity of examining the collections of Odonata made by the Northern Insect Survey, a co-operative project of the Canadian Department of Agriculture and the Canadian Department of National Defence. For this privilege I wish to express my thanks to Dr. G. P. Holland and the members of his staff in the Systematics Unit of the Division of Entomology, particularly to Dr. T. N. Freeman, co-ordinator of the Survey, and Mr. W. A. Brown for their kindness in providing laboratory facilities during visits to Ottawa and for shipping material to Toronto.

The collections of the Survey were made in 1947, 1949 and 1950, and comprise material taken in various localities across northern Canada from Labrador and Newfoundland to the Yukon Territory and the Mackenzie River delta. Not all the territory covered is subarctic but it is for the most part little known, or quite unexplored, as far as Odonata are concerned.

In 1943 the writer[1] summarized the published records of Odonata from the subarctic regions of North America and added a number of new ones. This was followed in 1947[2] by considerable additional material from the Mackenzie District, N.W.T., consisting chiefly of collections made in the summers of 1944, 1945 and 1946 in the course of a limnological survey of Great Slave Lake under the direction of the Fisheries Board of Canada. The survey was continued in

[1]Walker, E. M. The subarctic Odonata of North America. *Can. Ent.*, 1943, 75: 79-90.
[2]Walker, E. M. Further notes on the subarctic Odonata of North America. *Can. Ent.*, 1947, 79: 62-67.

1947, and it was in this year that the largest collection of Odonata was made. Since this collection contains additional records of some interest, they will be included in the present paper. The collection was made by Mr. J. R. Vockeroth, now on the staff of the Division of Entomology, Ottawa, who was also one of the most active collectors on the Northern Insect Survey.

As the material collected by the survey comes from a number of widely separated regions, it is desirable to list it in several sections. These will be given in order from west to east, the principal collections having been made in the more western regions. They are as follows:

1. Yukon Territory, with a few records from northern British Columbia and Alaska.
2. Mackenzie District, North-West Territory.
3. Northern Manitoba.
4. Southern James Bay, Ontario and Quebec.
5. Northern Quebec, Labrador and Newfoundland.

The names of the collectors, listed by initials, are as follows:

Beckell, W. E.	WEB	Le Roux, E. J.	EJL
Brown, W. J.	WJB	McAlpine, J. F.	JFM
Bruggemann, P. F.	PFB	Macleod, R. H.	RHM
Curtis, L. C.	LCC	Mason, W. R. M.	WRM
Freeman, T. N.	TNF	Mason & Hughes	M & H
Gray, D. P.	DPG	Munroe, E. G.	EGM
Hardwick, D. F.	DFH	Robertson, R. H.	RHR
Helps, W. G.	WGH	Smith, H. N.	HNS
Helps & Wallis	H & W	Teskey, H. J.	HJT
Hennigar, R. A.	RAH	Vockeroth, J. R.	JRV
Hicks, S. D.	SDH	Wallis, J. B.	JBW
Hughes, M. T.	MTH	Whillans, D. P.	DPW
Judd, W. W.	WWJ		

1. Yukon Territory, northern British Columbia and Alaska

(Unless otherwise indicated the records are from the Yukon Territory)

Lestes dryas Kirby. Dawson, 15 VII '49, 1 ♂ (PFB); 17 VII '49, 2 ♂ 2 ♀ (WWJ, PFB); 18 VII '49, 2 ♂ 1 ♀; do., 2000', 24 VII '49, 2 ♂ juv. (PFB).

Both mature and juvenile individuals were taken, the youngest ones on the latest date but from the highest altitude. In southern Canada it is an early spring species.

Lestes disjunctus Selys. Dawson, 17 VII '49, 2 ♂ 3 ♀ (WWJ); do., 1200', 26 VIII '49, 2 ♂ 1 ♀; do., 1500', 5 VIII '49, 1 ♂; Jensen Flats, Dawson, 2000', 24 VII '49, 2 ♂ 1 ♀, all juv. (PFB); Snag, 24 VII '48, 1 ♂ 1 ♀, both juv. (M & H).

These specimens are of about the same size as those from southern Canada.

Coenagrion resolutum Hagen. Whitehorse, 30 VI '48, 2 ♂ (WRM).

Enallagma boreale Selys. Whitehorse, 4 VII '48, ♂ ♀ paired (WJB); do., 11 VII '48, ♂ ♀ paired (MTH); 17 VI '50, 1 ♂ (RHR); Jensen Flats, Dawson, 2000', 24 VII '49, 2 ♂ 2 ♀ (PFB); Watson Lake, 17 VI '48, 1 ♀ (M & H). Lower Post, B.C., 16 VI '48, ♂ ♀ paired (M & H); Fort Nelson, B.C., 2 VII '48, 1 ♀ (WRM).

The females tend to be very heavily marked with black with the pale antehumeral stripes so narrow that such specimens appear like a very different species. These features are particularly marked in a female from Whitehorse and another from Watson Lake, and we have also observed them in females from other subarctic regions, such as Port Severn, Hudson Bay, Ont.

Enallagma cyathigerum Charp. Whitehorse, 4 VII '48, ♂ ♀ paired; Jensen Flats, Dawson, 1000', 24 VII '47, 2 ♂ (PFB); do., 2 VII '48, 1 ♂ (WJB).

Aeshna eremita Scudd. Whitehorse, 4 VII '48, 1 ♂ (WRM); 1 VII '50, 1 ♂ (Richard Hasse); Dawson, 2000', 21 VII '47, 1 ♂ (coll. ?); Squaaga (mi. 847, Alaska highway), 13 VIII '48, 1 ♀ (JBW).

Aeshna interrupta lineata Walk. Rock Creek, Dawson, 1300', 20 VII '49, 1 ♂ (PFB); Snag, 24 VII '48, 1 ♂ (M & H); Mayo, 1 VIII '49, 1 ♂ (coll. ?); Fort Nelson, B.C., 26 VIII '48, 1 ♀ (WRM); Haine, Alaska, 15 VII '46, 1 ♂ (JBW).

Aeshna juncea L. Dry Creek, 23 VII '48, 1 ♂ 1 ♀ (M & H); Dawson, 1500', 5 VIII '49, 1 ♂ (PFB); Haine, Alaska, 15 VII '48, 6 ♂ 20 ♀ (JBW).

This species, which is widespread and common in northern Canada, is remarkably uniform on this continent, showing no tendency towards subspeciation, as it does in Eurasia. Our subspecies is *americana* Bertenev.

Cordulia shurtleffi Scudd. Whitehorse, 4 VII '48, 1 ♀ (M & H); 4 VII '50, 1 ♂ (RHR); Watson Lake, 21 VI '48, 1 ♂ (WRM); Fort Nelson, B.C., 26 VIII '48, 1 ♀ (WRM).

Somatochlora albicincta Burm. Whitehorse, 16 VII '50, 1 ♂ (RHR).

Somatochlora hudsonica Hagen. Whitehorse, 4 VII '48, 1 ♂ (WRM); Jensen Flats, Dawson, 2000', 24 VII '49, 1 ♂ (PFB).

Leucorrhinia borealis Hagen. Dawson, 1500', 2 VII '49, 1 ♂ (coll. ?); Mayo, 8 VIII '49, nymph penult. stage. Fort Nelson, B.C., 10 VI '48, 1 ♀ (WRM).

Leucorrhinia hudsonica Selys. Dawson, 21 VI '49, 1 ♂ 1 ♀ (M & H).

Leucorrhinia proxima Calvert. Watson Lake, 21 VI '48, 2 ♂ (WRM); 17 VI '48, 2 ♂ 2 ♀ paired (M & H); Whitehorse, 1 VII '50, 3 ♂ (RHR, LCC); Lower Post, B.C., 17 VI '48, 2 ♀ (M & H).

2. Mackenzie District, North-West Territory

Records marked with an asterisk are from the Limnological Survey of Great Slave Lake, a project of the Fisheries Board of Canada.

Lestes congener Hagen. *Fort Resolution, G.S.L., 25 VII '47, 1 ♂ juv.; 22, 23 VIII '47, 4 ♂ 1 ♀; 28 VIII '47, 1 ♀ (JRV); *Pearson Pt., G.S.L., 4 VIII '47, 1 ♀ (JRV); Yellowknife, 5, 6 VIII '49, 2 ♀ (R. R. Hall).

These are the first records of this species from the North-West Territory and the most northerly for North America.

Lestes dryas Kirby. Fort Smith, 5 VII '50, 2 ♂ (WGH); Fort Simpson, '50, 5 ♂ 2 ♀ (DPW); Norman Wells, 27 VII '50, 5 ♂ 5 ♀ (WRM); all mature. *Fort Resolution, G.S.L., 25 VII '47, 9 ♂ 6 ♀, incl. 2 pairs; 23, 24 VIII '47, 5 ♂; *Gros Cap, G.S.L., 2 VIII '47, 1 ♀ (JRV).

Lestes disjunctus Selys. Fort Smith, 22 VI '50, 3 ♂ 2 ♀; 5 VII '50, 1 ♂ juv. (WGH); 22-28 VII '50, 14 ♂ 2 ♀ (JBW); Salt Plain, 21 VIII '50, ♂ ♀ paired (H & W); Norman Wells, 27 VII '50, 3 ♂ 2 ♀ (WRM). *Fort Resolution, G.S.L., 23-25 VII '47, 21 ♂ 2 ♀; 22, 23 VIII '47, 1 ♂ 3 ♀; *Gros Cap, G.S.L., 9, 10 VIII '47, 10 ♂ 1 ♀; *Jones Pt., G.S.L., 26 VIII '47, 2 ♀; *Wool Bay, 29 VII '47, 1 ♂ (JRV).

Of the July specimens six are more or less teneral, the others mature and in most cases already pruinose. The August specimens are all mature and nearly all pruinose.

Nehalennia irene Hagen. Fort Smith, 27-29 VI '50, 8 ♂ 2 ♀ (JBW); 5 VII '50, 2 ♂ 2 ♀ (JBW, WGH); 13 VII '50, 1 ♂ (JBW).

This species is new to the North-West Territory and Fort Smith is the most northerly locality from which it has been obtained.

Coenagrion resolutum Hagen. Fort Smith, 12-27 VI '50, 14 ♂ 9 ♀ (H & W); 5-29 VII '50, 4 ♂ 2 ♀ (JBW); Norman Wells, 23-27 VI '49, 1 ♂ 1 ♀ (SDH); 27 VII '50, 1 ♂ (WRM); Reindeer Depot, 5 VII '48, 1 ♀ (WJB). *Resolution, 16, 20 VI '47, 1 ♂ 1 ♀; 4 VII '47, 2 ♀ (JRV); *Resdelta, 22 VI '47, 15 ♂ 5 ♀ (JRV).

Reindeer Depot is the most northerly station known for this species and, in fact, for any North America species of Zygoptera.

Five of the males from Resdelta have the antehumeral stripes divided like an exclamation point; in the others of both sexes, from Great Slave Lake, they are entire, although in a few they are very nearly divided. No notes were made on this character in the case of the specimens from other localities, but both divided and entire stripes were common. This dividing of the stripes is just an expression of the general tendency in the far north for an increase in the extent of the black-pigmented areas.

Coenagrion interrogatum Hagen. Fort Smith, 27, 29 VI '50, 2 ♂ 2 ♀ (JBW); *Pearson Pt., G.S.L., 16, 17 VII '47, 10 ♂ 1 ♀ (JRV).

All have the antehumeral stripes divided and, on the whole, the specimens are heavily marked with black. They are of average or rather small size.

Coenagrion angulatum Walk. Fort Smith, 13 VI '50, 2 ♂ (H & W); 27, 29 VI '50, 1 ♂ 3 ♀ (JBW); *Resolution, 18-22 VI '47, 9 ♂ 6 ♀; 4, 5 VII '47, 4 ♂ 4 ♀ (JRV); *Resdelta, 22 VI '47, 11 ♂ 6 ♀ (JRV).

This species reaches a larger size at these latitudes than in the southern parts of the prairie provinces, particularly the females.

Enallagma boreale Selys. Fort Smith, 13 VI '50, 1 ♀: 27, 29 VI '50, 30 ♂ 17 ♀ (JBW); 4-7 VII '50, 2 ♂ 1 ♀ (H & W); 13 VII '50, 1 ♀ (WGH); 22, 27 VII '50, 4 ♂ (JBW); Norman Wells, 10 VII '49, 1 ♂ (SDH). *Resolution, 4 VII '47, 1 ♂; *Gros Cap, G.S.L., 30 VI '47, 1 ♂ (JRV).

The females are heavily marked, with the pale antehumeral stripes very narrow and a dark line on the metapleural suture.

Enallagma cyathigerum Charp. Fort Smith, 27-29 VI '50, 3 ♀; 5, 22 VII '50, 6 ♂ 2 ♀ (H & W). *Resdelta, G.S.L., 22 VI '47, 2 ♂ (JRV).

Ophiogomphus colubrinus Selys. Fort Smith, 31 VII '50, 2 ♂ 1 ♀ (JBW).

This is the only species of Gomphidae known from the North-West Territory.

Aeshna eremita Scudd. Fort Smith, 11-29 VI '50, 6 ♂ 3 ♀ (JBW); 5-27 VII '50, 11 ♂ 10 ♀ (H & W); Fort Simpson, '50, 1 ♀ (DPW); Norman Wells, 17 VII '49, 1 ♀; 20 VII '49, 2 ♂ (SDH); Reindeer Depot, 8-18 VII '48, 13 ♂ 13 ♀ (WJB, JRV). *Resolution and other stations on Great Slave Lake, viz., Gros Cap, Pearson Pt., Sachowis Pt., Jones Pt., Snowdrift and Hearne Channel, 4-30 VII '47, 26 VIII '47, 13 ♂ 13 ♀. Also 21 exuviae, 9, 10 VII '47 (JRV).

This is the earliest of the boreal Aeshnas to appear in flight and the earliest date hitherto recorded was June 27[1]. At Fort Smith three males were taken on June 11, 1950, and it would appear that, in the northern part of the range of *A. eremita*, the season of flight begins earlier than in the southern part. July is everywhere the month of its greatest abundance.

Aeshna interrupta lineata Walk. Fort Smith, 19-27 VI '50, 1 ♂ 1 ♀ (JBW); 5-31 VII '50, 14 ♂ 14 ♀ (H & W); Fort Simpson, '50, 3 ♀ (DPW); Norman Wells, 10 VII '49, 1 ♂ (SDH); Seven Mile Creek, 22 VIII '47, 1 ♂ (H & W). *Resolution, 4 VII '47, 2 ♀, 25 VIII '47, 1 ♂ (JRV); *Sachowis Pt., G.S.L., 18 VII '47, 1 ♀ (JRV); *Buffalo River, G.S.L., 25 VIII '47, 1 ♂ (JRV).

Aeshna juncea L. Fort Smith, 25 VI '50, 2 ♀; 1-2 VII '50, 3 ♀; 10, 12 VII '50, 15 ♂ (H & W); 17, 27 VII '50, 1 ♂ 2 ♀ (H & W); Fort Simpson, '50, 1 ♀

(DPW); Reindeer Depot, 12-19 VII '48, 12 ♂ 26 ♀; 2 VIII '48, 2 ♂ 1 ♀ (JRV). *Great Slave Lake, 1947: Pearson Pt., 16 VII, 1 ♂; Sachowis Pt., 18 VII, 1 ♀; Snowdrift, 17 VII, 1 ♂; Hearne Channel, 20 VIII, 1 ♀ (JRV).

Mr. Vockeroth tells me that *A. juncea* is the commonest Aeshna at Reindeer Depot, which is the most northerly locality where Odonata were collected.

Aeshna subarctica Walk. Reindeer Depot, 14 VII '48, 1 ♀ (JRV); *Gros Cap, G.S.L., 9, 15 VIII '47, 2 ♀ (JRV).

Aeshna sitchensis Hagen. Fort Smith, 6, 13 VII '50, 2 ♂ (H & W); Norman Wells, 13 VII '49, 1 ♀ (SDH). *Gros Cap, and Jones Pt., G.S.L., 26, 28 VIII '47, 2 ♀ (JRV).

Aeshna coerulea septentrionalis Burm. Reindeer Depot, 6, 12, 17 VII '48, 3 ♀; 7 VIII '48, 1 ♂ (JRV).

Cordulia shurtleffi Scudd. Fort Smith, 10-26 VI '50, 6 ♂ 23 ♀; 5 VII '50, 2 ♂ (H & W); Norman Wells, 28 VI '50, 1 ♀ (WRM). *Gros Cap, G.S.L., 20-30 VI '47, 4 ♂ 5 ♀; 7 VII '47, 1 ♂; *Snowdrift, G.S.L., 13 VII '47, 1 ♀ (JRV); Yellowknife, 24 VI '48, 1 ♂; 29, 30 VI '49, 4 ♀ (R. R. Hall).

Somatochlora kennedyi Walk. Fort Smith, 19-28 VI '50, 4 ♀ (JBW); Norman Wells, 23 VI '50, 1 ♀ (SDH).

Somatochlora sahlbergi Trybom. Reindeer Depot, 6 VII '48, 1 ♀; 8 VII '48, 2 ♂; 12 VII '48, 2 ♂ (WJB); 10 VII '48, 1 ♀; 13 VII '48, 1 ♂; 19 VII '48, 1 ♀ (JRV).

These are the first records of *S. sahlbergi* from Canada, but it was expected to occur here, as it had once been taken on the Kuskokwim River, Alaska[3]. Elsewhere it has been recorded from several stations on the Yenesei River, Siberia, by Trybom[4] and Valle[5], who has also reported it from the Kola peninsula and the Petsamo district in Russia, just east of the present boundary of Finland. All these Eurasian localities, as well as the Canadian one, are north of the Arctic Circle.

Somatochlora albicincta Burm. *Jones Pt., G.S.L., 21 VIII '47, 1 ♂ (JRV); Yellowknife, 29 VI '49, 1 ♂ (R. R. Hall).

Somatochlora hudsonica Hagen. Fort Smith, 12-16 VI '50, 1 ♂ 3 ♀ (JBW); 14 VII '50, 1 ♂ (WGH); Reindeer Depot, 6-8 VII '48, 3 ♂ 1 ♀; 11-16 VII '48, 3 ♂ 3 ♀ (WJB, JRV). *Resolution, 20 VI '47, 1 ♂; 5 VII '47, 1 ♂ (JRV).

Mr. Vockeroth tells me that this is the commonest Somatochlora in the Mackenzie Valley.

Libellula quadrimaculata L. Fort Smith, 9, 15 VI '50, 2 ♂ (JBW); 6, 9 VII '50, 2 ♂ 1 ♀ (H & W); Norman Wells, 28 VI '50, 1 ♀ (SDH). *Resolution, G.S.L., 20 VI '47, 1 ♀; 5 VII '47, 1 ♂ (JRV).

Sympetrum internum Montg. Fort Smith, 9, 12 VII '50, 2 ♀; 13 VII '50, 2 ♂ 2 ♀; 25 VII '50, 1 ♂ 1 ♀ (JBW); 28 VII '50, 1 ♂ (WGH); Fort Simpson, '50, 28 ♂ 9 ♀ (DPW); Norman Wells, 20 VII '49, 1 ♂ (SDH); 27 VII '50, 2 ♀ juv.; 3 VIII '50, 1 ♂ (WRM). *Yellowknife, G.S.L., 1 VII '47, ♂ just emerged, ♀ juv. (JRV); *Resolution, 24 VII '47, 2 ♂ 4 ♀; 23 ♂, 26 VIII '47, ♂ ♀ paired (JRV); *Jones Pt., G.S.L., 28 VII '47, 1 ♂; *Wool Bay, G.S.L., 1 VIII '47, 1 ♂ 2 ♀ (JRV).

This species, although common, tends to be small at these northern latitudes. The large series from Fort Simpson and those from Norman Wells are all undersized. They are all of the western form, in which the venation is reddish and the wings, particularly of the females, are frequently flavescent at base.

[3]Walker, E. M. The North American Dragonflies of the Genus Somatochlora. Univ. Toronto Studies, Biol. Ser. No. 26, 1925.

[4]Trybom, F. Trollsländor (Odonater) insamlade under Svenska Expeditionen till Jenesei 1876. Bihang till k. Svenska Vet. Akad. Handlingar, 1889, 15: 3-21.

[5]Valle, K. J. *Somatochlora sahlbergi* Trybom. *Notulae Entomologicae*, 1931, 11: 41-51.

Sympetrum obtrusum Hagen. Fort Simpson, '50, 14♂ 3♀ (DPW); Fort Smith, 25 VII '50, 1♂ (WGH). *Resolution, 24, 25 VII '47, 1♂ 1♀; 23 VIII '47, 1♂ (JRV); *Jones Pt., 26 VIII '47, 2♂ (JRV).

These are the first records of *S. obtrusum* from the North-West Territories. It is evidently very local and the specimens are usually small. The only considerable series, from Fort Simpson, is composed entirely of undersized individuals, like those of *S. internum.*

Sympetrum madidum Hagen. Fort Smith, 14 VII '50, 3♀; 31 VII '50, 2♀ (JBW); 19, 25 VII '50, 1♂ 1♀ (WGH); Fort Simpson, '50, 1♂ (DPW); Norman Wells, 20 VII '49, 1♂ (SDH). *Yellowknife, 1 VII '47, 1♀ (JRV); *Resolution, 22-25 VII '47, 6♂ 9♀; 27 VIII '47, 1♀ (JRV); *Wool Bay, G.S.L., 1 VIII '47, 1♂ (F. M. Atton).

This species was recorded from Great Slave Lake in 1947, from a single male, the discovery occasioning great surprise. It is evidently not at all rare and its large size is maintained throughout its range, so far as is known. The July specimens are all rather young, the lateral thoracic stripes being distinct. Those from Fort Simpson are fully mature and have lost the lateral stripes. They are not dated but were probably taken in August.

Sympetrum costiferum Hagen. *Resolution, 2, 9 VIII '47, 2♀; 22-24 VIII '47, 10♂ 11♀; 26 VIII '47, ♂ ♀ paired (JRV).

The specimens are of small size. A few, taken as late as Aug. 24, are teneral, and most of them are not quite mature, although in the majority the costal flavescence is absent or diffuse.

Sympetrum danae Sulzer. Salt Plain, 21 VIII '50, ♂ ♀ paired (JBW); Seven Mile Creek, 22 VIII '50, 1♂ (JBW). *Resolution, 22-25 VII '47, 5♂ 9♀; 9 VIII '47, 1♂ 5♀; 22-24 VIII '47, 10♂ 8♀ (JRV); *Gros Cap, G.S.L., 11 VIII '47, 1♂ (JRV); *Jones Pt., G.S.L., 26 VIII '47, 4♂ 2♀ (JRV).

All the specimens taken in the vicinity of Great Slave Lake in July are tenerals, except one male taken on the 25th. Specimens taken on Aug. 9 are still juvenile but the others captured in August are mature, except one female taken on the 26th. The majority taken during the last week in August are old, the males very black.

Leucorrhinia borealis Hagen. Fort Smith, 7-9 VI '50, 3♂ 2♀; 11 VI '50, 4♂ 4♀; 13-16 VI '50, 3♂ 8♀ (H & W); 13 VII '50, 1♀ (WGH); Norman Wells, 20 V '50, 1♂ juv. (WRM). *Resolution, 18, 20 VI '47, 5♂ 11♀ (JRV); *Resdelta, 22 VI '47, 1♂ 9♀ (JRV); *Gros Cap, 23 VI '47, 2♀ (JRV).

Although this is an early species to appear on the wing, the date of the specimen from Norman Wells, May 20, is probably a mistake for June 20. Even the June specimens are mostly somewhat teneral, particularly those from Great Slave Lake. The July specimens are all fully mature.

Leucorrhinia hudsonica Selys. Fort Smith, 9 VI '50, 2♀; 13 VI '50, 1♀ (JBW); Norman Wells, 16 VI '50, 1♂ 1♀, both juv. (SDH); 20-22 VI '49, 4♀ (WRM); 23 VI '50, 3♂; 10 VII '49, 1♂ (SDH); Reindeer Depot, 8 VII '48, 1♂ 1♀ (WJB). *Resolution, 18, 20 VI '50, 5♂ 1♀; 4 VII '47, 1♂ (JRV); *Gros Cap, G.S.L., 30 VI '47, 3♂ 1♀; 4 VII '47, 1♂ (JRV); Pearson Pt., G.S.L., 16, 17 VII '47, 8♂ 4♀ (JRV).

This is another species to emerge early, perhaps even earlier than *L. borealis*, the specimens taken at Resolution on June 18 and 20 being more mature than those of *L. borealis.* Tenerals were taken with adults as late as June 30. A pair *in copula* was taken at Pearson Pt. on July 16.

Leucorrhinia patricia Walk. Norman Wells, 16 VI '50, 1 ♂ 1 ♀ (SDH). *Gros Cap, G.S.L., 30 VI '47, 1 ♀ (JRV); *Pearson Pt., 16, 17 VII '47, 3 ♂ 3 ♀ (JRV).

The specimens from Norman Wells, like those of *L. hudsonica* taken on the same day, are tenerals, having emerged within a day of their capture. This is the most northerly record for *L. patricia.*

Leucorrhinia proxima Calvert. Fort Smith, 27 VI '50, 1 ♂ 1 ♀ (JBW); 13 VII '50, 1 ♂ (WGH). *Pearson Point, G.S.L., 17 VII '47, 1 ♀ (JRV).

3. Northern Manitoba, 1947-1950

Lestes disjunctus Selys. Wabowden, 8 VIII '49, 1 ♂ 1 ♀ (JBW); Gillam, 11 VIII '50, 2 ♂ 1 ♀ (JFM).

Coenagrion resolutum Hagen. Wabowden, 5 VIII '49, 1 ♂ (JBW); Gillam, 19 VI '49, 1 ♀ (JBW); 7, 11 VII '50, 2 ♀; 24 VII '50, ♂ ♀ paired (JFM); Churchill, 19 VI '50, 16 ♂ 13 ♀ (JBW).

Enallagma boreale Selys. Wabowden, 2, 5, 15 VIII '49, 4 ♂ 2 ♀ (JBW); Gillam, 3 VII '50, 1 ♂; 11 VII '50, 3 ♂ 1 ♀; 24 VII '50, ♂ ♀ paired (JFM); Herchmer, 5 VII '49, 1 ♀ (JBW).

The females from Wabowden are very heavily marked with black, like those from the Mackenzie District, while the males are remarkable for the almost horn-like prominence of the oblique ridge on the dorso-mesal surface of the superior anal appendages. We are inclined, for the present, to regard this variation as probably a local one.

Enallagma cyathigerum Charp. Wabowden, 5 VIII '49, 1 ♀ (JBW); Gillam, 8 VII '50, 1 ♂ (JFM).

Ophiogomphus colubrinus Selys. Gillam, 14, 20, 30 VII '50, 1 ♂ 2 ♀ (WJB); 11, 14 VIII '50, 2 ♂ 1 ♀ (JFM).

Aeshna eremita Scudd. Lake Atikameg, 14 VIII '49, 2 ♂ 6 ♀ (JBW); Blue Lakes, 31 VIII '49, 1 ♀ (JBW); Gillam, 28 VII '49, 1 ♂ (JBW); 14, 20 VII '50, 1 ♂ 1 ♀ (JFM).

Aeshna interrupta lineata Walk. Lake Atikameg, 14 VIII '49, 2 ♂ 2 ♀ (JBW); Blue Lakes, 14, 31 VIII '49, 2 ♂ (JBW); Pikwitonei, 30 VII '49, 1 ♂ (JBW); Dixitown, 30 VII '49, 1 ♀ (JBW).

Aeshna canadensis Walk. Lake Atikameg, 14 VIII '49, 2 ♂ 8 ♀ (JBW). This is the most northerly station known for this species.

Aeshna juncea L. Lake Atikameg, 14 VIII '49, 1 ♀ (JBW); Pikwitonei, 31 VII '49, 1 ♂ (JBW); Dixitown, 30 VII '49, 1 ♀ (JBW); Gillam, 25 VII '50, 1 ♂, 11 VIII '50, 1 ♀ (JFM); Churchill, 13 VII '50, 1 ♀ (C. W. Cottershill); 2 VII '50, 4 ♂ (HJT).

Aeshna subarctica Walk. Gillam, 31 VII, '50, 1 ♀; 8 VIII '50, 2 ♂ (JFM).

Aeshna sitchensis Hagen. The Pas, 18 VIII '49, 1 ♀ (JBW); Lake Atikameg, 14 VIII '49, 2 ♀ (JBW); Gillam, 5, 19, 27 VII '50, 3 ♂; 11 VIII '50, 1 ♂ 1 ♀ (JFM); 29 VII '49, 1 ♀ (JBW); Churchill, 7 VII '49, 1 ♀ (JBW); 13, 14, 20 VII, '50, 3 ♀ (C. W. Cottershill).

Aeshna coerulea septentrionalis Burm. Herchmer, 5 VII '49, 1 ♂ (JBW); Churchill, 25 VII '50, 1 ♀ juv. (HJT).

Cordulia shurtleffi Scudd. Gillam, 22 VI '49, 1 ♀ (JBW); 5 VII '50, 2 ♀ (JBW); Churchill, 25 VIII '50, 1 ♀, juv. (HJT).

The last date would be far past the season of this species in southern Canada, and appears to be unusual even at the latitude of Churchill.

Somatochlora minor Calv. Gillam, 19, 21 VII '50, 3 ♂ (WJB).

Somatochlora franklini Selys. Gillam, 11, 15 VII '50, 2 ♂ 1 ♀ (JFM); 4, 19, 20 VII '50, 2 ♂ 1 ♀ (WJB); 24 VII '49, 1 ♀ (JBW); Churchill, 6, 9 VII '49, 1 ♂ 3 ♀ (JBW).

This frail species is decidedly the most abundant Somatochlora of the Hudson Bay region.

Somatochlora septentrionalis Hagen. Churchill, 25 VII '50, 1 ♀ (HJT).

Somatochlora hudsonica Hagen. Churchill, 19, 21 VII '50, 4 ♀, all juv. (HJT).

Somatochlora cingulata Selys. Gillam, 3 VII '50, 1 ♀ juv., 2 ♀; 14 VII '50, 1 ♂ juv.; 20-26 VII '50, 7 ♂ (JFM, WJB); 24 VII '49, 3 ♂ (JBW).

Libellula quadrimoculata L. The Pas, 18 VIII '47, 1 ♀ (JBW).

Sympetrum internum Montg. Wabowden, 5, 7 VIII '49, 3 ♂ 4 ♀ (JBW); Gillam, 11, 12 VIII '50, 1 ♂ 2 ♀, ♂ ♀ paired (JBW).

The specimens from Wabowden are small, as shown by the following measurements: abdomen ♂ 17.5 mm., ♀ 19.0; hind wing, ♂ ♀ 22 mm.

Sympetrum costiferum Hagen. Blue Lakes, 31 VIII '49, 1 ♂ 6 ♀ (JBW).

Sympetrum danae Sulzer. Blue Lakes, 31 VIII '49, 2 ♂ 1 ♀ (JBW); Wabowden, 5 VIII '49, 1 ♂ (JBW).

Leucorrhinia hudsonica Selys. Gillam, 15 VI '49, 1 ♀ juv.; 22 VI '49, 1 ♂ (JBW); 5 VII '49, 1 ♂ (JBW); 13 VI '50, 1 ♀; 29, 30 VI '50, 3 ♂ 1 ♀; 3-27 VII '50, 4 ♂ 1 ♀ (JFM, WJB); Herchmer, 29 VI '49, 4 ♂; 4, 5, 6 VII '49, 3 ♀ (JBW); Churchill, 24 VII '50, 1 ♂ 1 ♀ (HJT).

Leucorrhinia patricia Walk. Gillam, 27 VI '50, 1 ♂ (WJB). This is the first record for Manitoba.

Leucorrhinia proxima Calv. Gillam, 3 VII '50, 1 ♂ (WJB).

4. James Bay: Moosonee and Moose Factory, Ont.; and Rupert House, Que. (1949)

Nehalennia irene Hagen. Rupert House, 3 VII, 1 ♂ (DPG).

Not previously recorded in eastern Canada north of Favourable Lake.

Coenagrion resolutum Hagen. Moose Factory, 4 VI, 1 ♂ juv.; 9 VI, 3 ♂ (EJL); 23 VI, 2 ♂ 2 ♀ (DPW, DFH).

Enallagma ebrium Hagen. Rupert House, 3 VII, 5 ♂ 2 ♀ (DPG).

Not previously known north of Smoky Falls, Cochrane Dist., Ont. (N. Lat. 50°).

Ischnura verticalis Say. Moose Factory, 4 VII, 1 ♀ (EJL).

This record is somewhat surprising since this species, so abundant in southern Quebec and Ontario, was hitherto unknown north of Orient Bay, Lake Nipigon, the Lake of the Woods, and Victoria Beach, Lake Winnipeg.

Aeshna eremita Scudd. Rupert House, 13 VIII, 1 ♂ (EJL).

Aeshna juncea L. Rupert House, 6, 8 VII, 2 ♂ (EJL).

Aeshna sitchensis Hagen. Rupert House, 4 VI, 1 ♀; 15 VI, 2 ♀ (DPG); 16 VI, 2 ♂ (EJL, HNS); 22 VI, 1 ♂ (EJL); 23 VI, 1 ♀ (DFH).

The first date, June 4, is apparently the earliest known for the emergence of this species.

Cordulia shurtleffi Scudd. Moose Factory, 1 ♂ (EJL); Rupert House, 15-18 VI, 1 ♂ 3 ♀ (DPG, EJL); 23 VI, 1 ♀ (DFH).

The time of flight of this species seems to be much the same here as it is near its southern limit.

Somatochlora franklini Selys. Moose Factory, 18-23 VI, 4 ♂ 11 ♀ (DPW, DFH); 24 VI, 23 ♂ 57 ♀ (DPW); Rupert House, 7 VI, 1 ♂ 1 ♀ (DPG, EJL): 14-24 VI, 3 ♂ 6 ♀ (DPG, EJL).

As usual with this species, considerably more females than males were taken.

Williamsonia fletcheri Wmsn. Moose Factory, 9 VI, 1 ♀ (EJL).

This small glacial relict had not been taken before in Ontario north of Lake Timagami.

Libellula quadrimaculata L. Moose Factory, 9 VI, 1 ♀ (EJL); 23 VI, 1 ♂ (DFH).

Leucorrhinia hudsonica Selys. Moose Factory, 9 VI, 1 ♀ (EJL); 23 VI, 2 ♂ 2 ♀ (DPW, DFH).

5. Northern Quebec (1948), Labrador (1948) and Newfoundland (1949)

Lestes disjunctus Selys. Goose Bay, Labr., 16 VIII, 1 ♂ 1 ♀ (WEB); 25 VIII, 2 ♂ (coll. ?); Gander, Nfld., 18 VII, 1 ♀ (RAH).

The Goose Bay record is the first in Labrador for this species and, in fact, any species of the suborder Zygoptera.

Coenagrion resolutum Hagen. Knob Lake, Que. (54° 47′ N. Lat., 66° 47′ W. Long.), 8 VII, 1 ♂ (EGM).

This is the most northerly record for any species of Zygoptera in Quebec.

Aeshna eremita Scudd. Gander, Nfld., 19 VII, 1 ♂ (RAH).

Aeshna juncea L. Fort Chimo, Ungava Bay, Que., 6 VI, 1 ♀ (HNS); 9 VIII, 2 ♂ 1 ♀ (RHM); Knob Lake, Que., 27 VII, 1 ♂ (WEB); Great Whale River, Que., 1 VIII '49, 1 ♂ 1 ♀ (JRV); Goose Bay. Labr., 27 VII, 1 ♂ (WEB).

Aeshna sitchensis Hagen. Great Whale River, Que., 1 VIII '49, 2 ♂ (JRV).

Aeshna coerulea septentrionalis Burm. Fort Chimo, Que., 10 VII, 1 ♂ juv. (RNM); 23 VII, 1 ♂ (HNS); 29 VII, 9 ♂ 1 ♀ (RNM); 9 VIII, 2 ♂ 3 ♀ (RNM); 8 VIII, 1 ♀ (HNS); 1 ♂ without date.

Aeshna umbrosa Walk. Gander, Nfld., 24 VIII, 2 ♀ (RAH).

Somatochlora franklini Selys. Fort Chimo, Que., 23, 24 VII, 2 ♀ (HNS).

Somatochlora albicincta Burm. Fort Chimo, Que., 23 VII, 1 ♂; 9 VIII, 1 ♂ (HNS); Knob Lake, Que., 27 VII, 1 ♀ (EGM); Great Whale River, Que., 1 VIII, '49, 2 ♂ 2 ♀ (JRV).

Cordulia shurtleffi Scudd. Gander, Nfld., 8 VII, 1 ♂ (RAH).

Libellula quadrimaculata L. Goose Bay, Labr., 9 VII, 1 ♀ (WEB).

This is the first record from Labrador of this common circumpolar species.

Sympetrum internum Montg. Gander, Nfld., 13 VIII, 2 ♀ (RAH).

Sympetrum costiferum Hagen. Gander, Nfld., 13 VIII, 1 ♀ (RAH).

Sympetrum danae Sulzer. Gander, Nfld., 14 VIII, 2 ♂, one a teneral (RAH).

Leucorrhinia hudsonica Selys. Fort Chimo, Que., 7 VII, 1 ♀ (HNS); Knob Lake, Que., 7 VII, 1 ♂ (TNF); 12 VII, 1 ♂ (EGM); Goose Bay, Labr., 14 VI, 1 ♀, very teneral (WEB); 17 VI, 1 ♀ juv.; 28 VI, 1 ♂ (WWJ).

In the above lists only forty species are enumerated and yet this small number is probably not far short of the total number of species of Odonata that inhabit the vast territory represented by the five lists. The only species of the general boreal fauna that might have been expected but were not collected are *Somatochlora forcipata* Scudd., *S. whitehousei* Walk. and possibly *S. walshii* Scudd., all of them widely distributed across the Continent. The last-named species is found as far north as James Bay but probably does not reach much of the territory covered in the Survey; but the other two are certainly to be expected. There are also the Cordilleran species *Aeshna palmata* Hagen and *Somatochlora semicircularis* Selys, both common in British Columbia and ranging into Alaska. They should be found in the Yukon Territory but probably do not occur far eastward.

On the other hand there is about an equal number of species on the lists that can scarcely be considered as belonging to the fauna of the high north. They are not, at any rate, Hudsonian or subarctic. Belonging to this category are *Enallagma ebrium* Hagen, *Oschnura verticalis* Say, *Aeshna canadensis* Walk. and perhaps *Williamsonia fletcheri* Wmsn., a rare glacial relict, of which little is known.

We have already pointed out[1] that the relationship of this northern odonate fauna with the corresponding palaearctic group is very close, all of the species belonging to holarctic genera and many of them being circumpolar or having very close palaearctic relatives.

From the ecological point of view it may be noted that all the species except one are inhabitants of bog ponds, bog-margined lakes, shallow marshy waters or slow streams. The single species of rapid streams is *Ophiogomphus colubrinus* Selys. One other stream form, *Agrion aequabile* Say, has been taken as far north Fort Albany, James Bay, but in general the streams in these northern latitudes appear to be too cold for dragonfly nymphs.

Mordellidae of Prince Edward County, Ontario (Coleoptera)

By J. F. Brimley
Wellington, Ont.

While rearranging a collection of Mordellidae taken in Prince Edward County, Ontario, during many years of collecting, it was found that records from Canada were few in the publications available. Perhaps the following records will add a little to the knowledge of distribution of this group. The nomenclature and arrangement follow Liljeblad (1945, Univ. Michigan Mus. Zool. Misc. Publ. 62).

Glipa Lec.

bidentata (Say). Taken during June and July on trunks of dead beech.

Mordella L.

quadripunctata (Say). July 18; one only.

melaena Germ. Fairly numerous from June to August.

marginata Melsh. Common on blossoms from June to August; the variety *lineata* Melsh. is less numerous.

atrata Melsh. Plentiful, June to September; the variety *lecontei* Csiki, June and July.

Tomoxia Costa

inclusa Lec. Taken during June and July; seen emerging from dead basswood.

borealis (Lec.). Taken only in August.

lineella Lec. Beaten from limbs of dead hard maple; June to August.

serval (Say). Found from June to August on ironwood stumps and dead beech.

triloba (Say). Taken during July and August on dead ironwood and black cherry.

discoidea (Melsh.). One only, August 1.

Mordellistena Costa

bicinctella Lec. Beaten from red oak during June and July.

trifasciata (Say). Taken by beating in July and August.

scapularis (Say). Numerous on blossoms from May to August.

limbalis (Melsh.). Beaten from hickory, June to August.

fulvicollis (Melsh.). Fairly numerous during July and August.

vapida Lec. July and August.

pallipes Sm. One only, July 28.

ornata (Melsh.). The most plentiful of the genus; taken from June to September.

cervicalis Lec. Scarce, June to August.

aspersa (Melsh.). Numerous during June and July; taken by beating and from blossoms of Canada thistle.

tosta Lec. Taken from June to August.

picilabris Helm. July 24.

andreae Lec., variety *ancilla* Lec. Plentiful during July and August on hickory and red oak.

nigricans Melsh. July.

testacea Blatch. One only, August 16.

smithi Dury. Fairly numerous during July and August.

pustulata (Melsh.). Taken by beating and from blossoms of Canada thistle; July to August.

discolor (Melsh.). One only, July 5.

fuscipennis (Melsh.). Scarce; July and August.

unicolor Lec. July.

Anaspis Geoff.

flavipennis Hald. Numerous on blossoms from May to July.

rufa Say. Numerous on blossoms; May to July.

Species that have been taken in other parts of Ontario, and that may be taken eventually in Prince Edward County, are: *Glipa oculata* (Say), *Mordellistena convicta* Lec., *M. marginalis* (Say), and *Larisia nigricolor* Lilj.

A Report on Mites Infesting the Muskrat (*Ondatra zibethica osoyoosensis*) in British Columbia

By Iola W. Musfeldt Knight

During the course of a survey on the diseases and internal parasites of muskrats in British Columbia (1951), twelve muskrats trapped by the author were also examined for the presence of external parasites.

All of these animals were considered in a healthy condition. There was no apparent inflammation of the eyes, ears or nostrils. The fur was not yet in prime condition but it was sleek, with no evidence of skin disease.

It was found that ectoparasites, when present, were most numerous in the abdominal region. Juvenile and female animals were found to be less parasitized than the adults and males. In this connection, the most heavily parasitized male juvenile muskrat harboured an estimated 50 mites per $cm.^2$ while a female juvenile animal was non-parasitized. However, the most heavily infested male adult muskrat averaged 100 mites per $cm.^2$ whereas an adult female was infested by an estimated one quarter of this number.

Identification of the ectoparasites by H. H. J. Nesbitt revealed mites from the following genera of Acarina: *Laelaps multispinosus* Banks (= *L. spiniger* Ewing); *Dermacerus validus* (Banks); *Listrophorus americanus* Radford; *Eutrombicula harperi* (Ewing) and a species of *Radfordia* which closely resembles *leminia* (C. L. Koch).

Of these species, only *Listrophorus* sp. has been previously reported a parasite of the muskrat. This report was made by Smith (1938) in Maryland, where it was identified by H. E. Ewing as a new species of the hairclasping mites belonging to the genus *Listrophorus*. This mite was one of the more prevalent ones on the muskrats at Burnaby Lake area. However, *E. harperi* and *Radfordia*

sp. have been considered the least abundant of the mites affecting this host in this area, being represented by one specimen each when identified. On the other hand, *D. validus* was found to be the most abundant species, greatly outnumbering the others. It was this mite that was observed, a few days after the first examination, clinging to the hair of the heavily infested female muskrat mentioned above.

There was a noticeable absence of other mites previously reported as parasites of muskrats, especially *Tetragonyssus spiniger* which is prevalent in the eastern United States. It was reported by Svihla and Svihla (1931) and Penn (1942) in Louisiana muskrats as well as by Smith (1938) in Maryland. According to Svihla and Svihla this species was found on practically all of the muskrats examined, even the young in the nest. These authors state that it "seemed to attack chiefly the eyelids of the muskrat." However, Smith (1938) reported that the muskrats contracted an inflammation of the eyes, for which he did not define the cause.

Summary

Five species of mites were found as the result of the examination of twelve muskrats from Burnaby Lake (Vancouver), British Columbia. These species were *Laelaps multispinosus* Banks (= *L. spiniger* Ewing); *Dermacerus validus* (Banks); *Listrophorus americanus* Radford; *Eutrombicula harperi* (Ewing); and a species of *Radfordia* closely resembling *leminia* (C. L. Koch).

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